MTM

The Journal of Methods-Time Measurement

MTM ASSOCIATION FOR STANDARDS AND RESEARCH

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In This Issue . . .

The Journal of Methods-Time Measurement is dedicated to the technical aspects, application developments and general news items concerning the advancement of MTM.

The Journal encompasses the fields of endeavor that were formerly publicized in the MTM Newsletter and MTM Bulletin.

The technical section of the Journal is concerned chiefly with recent research developments both from the established research program at the University of Michigan, Ann Arbor, Michigan, and from somewhat smaller allied projects being conducted throughout the Association membership.

New applications of MTM as well as refinements of established applications are presented in the Application Section to illustrate specific approaches to management problems that can be solved through the use of Methods-Time Measurement.

Current events in the lives of persons associated with MTM are described in the general news section.

The Editorial Staff welcomes contributions for all three sections described.

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MTM

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Editor's Note:

The Association has tried in every way possible to check the veracity of material published in the Journal of Methods Time Measurement. However, the opinions of the authors are not necessarily the opinions of the Association. The Association, therefore, will not be held responsible for any liability which may develop from any material in this publication.

Reading from left to right: John A. Willard, President, MTM Association; Dr. Gilbreth; Benjamin Borchardt, Vice President, MTM Association; D. W. Karger, Director, MTM Association; Richard F. Stoll, Executive Secretary, MTM Association.

FEATURE

OPERATING TIME FORMULA REPORT

Drill, Jigs, Milling Fixtures, Turret, Lathe Fixtures

D. H. Halliar
NOPF Standards Department
U.S. Naval Ordnance Depot
Forest Park, Illinois

There has been continued interest in Time Formula development, and the use of MTM. D. H. Halliar, U.S. Naval Ordnance Depot Engineer, has developed interesting Time Formulae for Jigs and Fixtures. The following formulae are offered to the Journal readers as approach to use of MTM in formulae development.

APPLICATION: All jigs used on sensitive drill press, L & G #1 and #2.

OPERATION: Operating time for Drill Jigs.

ALLOWED TIME: Each piece—see Work Sheet.

Time values given in this formula pertain only to inserting, removing, and securing parts in fixtures.

DATA SHEET

DRILL JIGS AND FIXTURES

K-7	Use type I Fixture	.0006	Complex type I	.0016
K-11	Use type II Fixture	.0012		
K-24	Use type III Fixture (Small)	.0013		
K-25	Use type III Fixture (Large)	.0014		
K-26	Use type IV Fixture	.0015		

ADDITIONAL LOCATING

K-42	Pin part with Locating Pin	.0015

CLAMPING

K-27	Open and close leaf with one-quarter turn thumb screw	.0011
K-28	Open and close leaf (no fastening device)	.0004
K-29	Remove and replace top plate with two one-quarter turn thumb screws	.0024
K-32	Position and remove small turn clamp with nut	.005
K-33	Position and remove small turn clamp with Allen Head cap screw	.004
K-34	Remove and replace nut on bolt	.0007
K-35	Open and close quick acting clamp	.0011
K-36	Tighten and loosen Allen Head cap screw	.0034
	Tighten and loosen each additional screw	.0030
K-37	Tighten and loosen bolt or nut one-half inch	.0043
	Tighten and loosen each additional one-half inch	.0007
K-38	Remove and replace sliding clamp	.0053
K-39	Tighten and loosen knurled head hand screw (hand tight)	.0016
K-40	Tighten and loosen knurled head hand screw (with wrench)	.0026
K-41	Insert and remove drill bushing	.0014

WORK SHEET INSTRUCTIONS

1. Determine type of fixture to be used.
2. Determine additional locating, such as, pin part.
3. Determine method of securing part in fixture.
4. Select time values of above, add, and allow for each piece.

EXAMPLE:			
	Type I Fixture		.0006
Open and close leaf with one-quarter turn thumb screw	K-27		.0011
Tighten and loosen knurled head hand screw (hand tight)	K-39		.0015
2 Allen Head cap screws	K-36	.0034 x 2	.0068
			.0100 each piece

If an element occurs more than once, the value will have to be multiplied by the number of occurrences. See above example (K-36).

All time values given in Data Sheet are leveled times, without allowances.

ANALYSIS

The time values developed in this formula are based on the study of approximately fifteen hundred drill jigs normally used on the sensitive drill press.

Due to the wide variety of jigs encountered, an individual formula was needed to develop accurate operating times for all jigs.

After a preliminary study, it was obvious that the greater percent of the jigs could be classified into four basic types. These four types are listed below and will be described fully later:

(1) Box Jigs
(2) Sandwich Jigs
(3) Pump Jigs
(4) Plate Jigs

In all four types, a wide variety of clamping devices are used, such as leaf gates, leaf gates with one-quarter turn thumb screws, Allen screws, etc. In one jig alone, several different devices might be used.

Individual MTM studies covering the operation of each of the different types of clamping devices were made. These studies were taken by observing the many different locations of the clamping devices used and establishing average time values.

Values given in the table of elements are total values. They include both the insertion and removal of parts, tightening and loosening of screws, etc.

TYPES AND DESCRIPTIONS

All drill jigs and fixtures have been classified into four types:

(1) Box Jigs
(2) Sandwich
(3) Pump
(4) Plate

If other means of work holding are used, time values may be synthesized from the Table of Elements.

FEATURE

TYPE I

BOX JIG

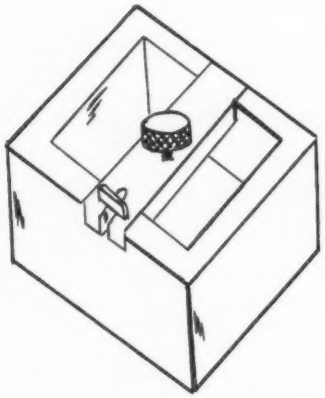
A standard box jig usually consists of four sides and a bottom. The piece part is usually inserted into the cavity from the top.

Parts may be positioned in many different manners: over a pin or pins, against locators, into a vee, etc., depending on the characteristics of the piece part.

The time required to fit a part to a box jig is primarily determined by part symmetry and the closeness of fit.

The top of a box jig usually consists of a hinged leaf or gate, hinged or removable cover, and/or one of the various types of clamps. The locking device for the piece part is usually located on the top of the jig.

A complex Type I fixture occurs when heavy pressure and compound positioning are required to seat piece part in fixture.



This sketch is intended to be used only as a guide in selecting fixture types. It only portrays identifying characteristics of the Type I fixture. Type I fixtures will vary for the purpose and nature of the work.

TYPE II

FLAT SANDWICH DRILL PLATE

Flat sandwich-type drill plates usually consist of a top and bottom plate, one stationary diamond pin on one end, and a removable pin on the other.

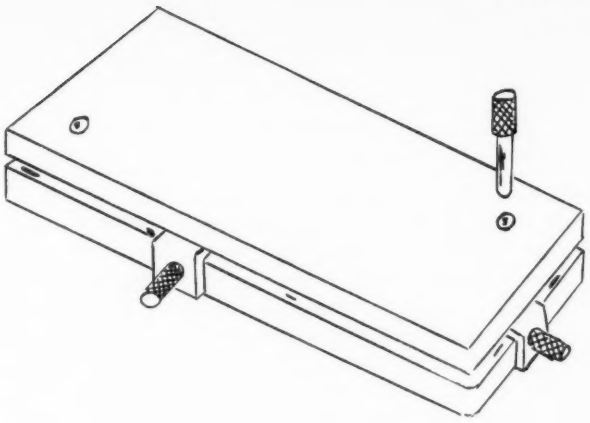
The piece parts drilled in this type of jig are usually flat and rectangular. Parts range in thickness from 1/16" to 1/4".

The piece part is positioned against solid locators (pins). It is secured by tightening clamps on two sides.

The time required to fit a part to this type jig is the same for all sizes. All parts are semi-symmetrical.

The top of this jig consists of a plate, which is located over the piece part by positioning it over a solid stationary diamond pin protruding from the bottom plate.

A removable pin is inserted through the liners of both plates, thus completing the location.



This sketch is intended to be used only as a guide in selecting fixture types. It only portrays identifying characteristics of the Type II fixture. Type II fixtures will vary with the purpose and nature of the work.

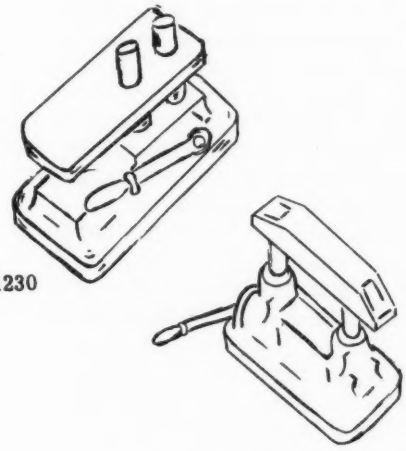
TYPE III

PUMP JIGS

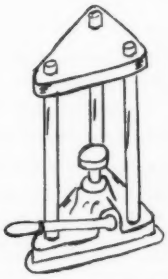
The universal pump jigs used at this activity are numbered MA 1230 - 1231 - 1283 and 1588. MA 1230 and 1231 are considered as small pump jigs, and 1283 and 1588 are considered to be large pump jigs.

All but 1283 contain a solid base, two upright posts, and a removable top plate. These jigs may be used for various jobs by changing the top plate and lower adapter. An upward swing of the handle raises the top plate, a downward swing lowers it, locating and clamping the work securely.

Jig 1283 has three equally spaced posts mounted in a triangular base. The handle operates a plunger that is in the center of the base. A lower adapter is mounted on the top of this plunger. The top plate is mounted on top of the three posts. The work is clamped tightly up against the top plate by moving the handle down.



MA 1230



MA 1283

MA 1231 and 1588

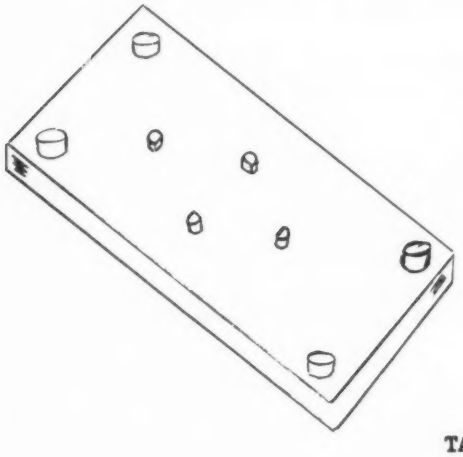
FEATURE

TYPE IV

FLAT DRILL PLATE

This is generally a flat rectangular steel plate with positive stop locating pins. The part has to be forced between the pins. No clamping is usually needed because of the force fit of the part between the pins.

Parts are inserted from the bottom; therefore, the jig must be turned over for loading and unloading.



This sketch is intended to be used only as a guide in selecting fixture types. It only portrays identifying characteristics of the Type IV fixture. Type IV fixtures will vary with the purpose and nature of the work.

TABLE OF ELEMENTS

A	Insert loose symmetrical part (Type I Fixture).	31.8
B	Insert close fitting symmetrical part (Type I Fixture).	42.4
C	Insert loose fitting semi-symmetrical part (Type I Fixture).	40.9
D	Insert close fitting semi-symmetrical part (Type I Fixture).	51.5
E	Insert loose fitting non-symmetrical part (Type I Fixture).	42.2
F	Insert close fitting non-symmetrical part (Type I Fixture).	52.8
G	Insert tight fitting complex part (Type I Fixture).	107.2
H	Insert close fitting semi-symmetrical part (Type II Fixture).	31.7
I	Insert loose symmetrical part (Small Type III Fixture).	69.8
J	Insert close symmetrical part (Small Type III Fixture).	80.4
L	Insert loose semi-symmetrical part (Small Type III Fixture).	73.3
M	Insert close semi-symmetrical part (Small Type III Fixture).	83.9
N	Insert loose non-symmetrical part (Small Type III Fixture).	74.6
O	Insert close non-symmetrical part (Small Type III Fixture).	85.2
P	Insert loose symmetrical part (Large Type III Fixture).	72.5
Q	Insert close symmetrical part (Large Type III Fixture).	76.0
R	Insert loose semi-symmetrical part (Large Type III Fixture).	76.0
S	Insert close semi-symmetrical part (Large Type III Fixture).	83.1
T	Insert loose non-symmetrical part (Large Type III Fixture).	77.3
U	Insert close non-symmetrical part (Large Type III Fixture).	87.9
V	Insert close non-symmetrical part (Type IV Fixture).	79.6
W	Remove loose symmetrical part (Type I Fixture).	10.9
X	Remove close symmetrical part (Type I Fixture).	10.9
Y	Remove loose semi-symmetrical part (Type I Fixture).	10.9
Z	Remove close semi-symmetrical part (Type I Fixture).	14.4

TABLE OF ELEMENTS
(Continued)

A-1	Remove loose non-symmetrical part (Type I Fixture).	10.9
B-1	Remove close non-symmetrical part (Type I Fixture).	14.4
C-1	Remove tight complex part (Type I Fixture).	51.1
D-1	Remove close semi-symmetrical part (Type II Fixture).	19.3
E-1	Remove loose symmetrical part (Small Type III Fixture).	52.6
F-1	Remove close symmetrical part (Small Type III Fixture).	56.1
G-1	Remove loose semi-symmetrical part (Small Type III Fixture).	52.6
H-1	Remove close semi-symmetrical part (Small Type III Fixture).	56.1
I-1	Remove loose non-symmetrical part (Small Type III Fixture).	52.6
J-1	Remove close non-symmetrical part (Small Type III Fixture).	56.1
L-1	Remove loose symmetrical part (Large Type III Fixture).	59.4
M-1	Remove close symmetrical part (Large Type III Fixture).	66.9
N-1	Remove loose semi-symmetrical part (Large Type III Fixture).	63.4
O-1	Remove close semi-symmetrical part (Large Type III Fixture).	66.9
P-1	Remove loose non-symmetrical part (Large Type III Fixture).	63.4
Q-1	Remove close non-symmetrical part (Large Type III Fixture).	66.9
R-1	Remove close non-symmetrical part (Type IV Fixture).	65.8
S-1	Open and close leaf on Small Type I Fixture with one-quarter turn thumb screw.	108.6
T-1	Open and close leaf gate, no fastening device. Closed to a stop.	42.2
U-1	Remove and replace top plate from Type I Fixture with two one-quarter thumb screws.	237.7
V-1	Remove and replace top plate on Type II Fixture and lock with pin (small).	51.1
W-1	Remove and replace top plate on Type II Fixture and lock with pin (large).	87.3
X-1	Position and remove dog clamps.	32.4
Y-1	Remove and replace nut on bolt.	71.2
Z-1	Open and close quick acting clamp.	107.8
A-2	Tighten and loosen Allen Head cap or set screw.	343.1
	Tighten and loosen each additional Allen Head cap or set screw.	298.0
B-2	Tighten and loosen bolt or nut run down with fingers one-half inch.	429.3
C-2	Position and remove sliding clamps. Spring pressure on bolt.	96.2
D-2	Tighten and loosen knurled head hand or thumb screw.	164.2
E-2	Tighten or loosen knurled head hand or thumb screw with bar wrench or pliers.	91.5
F-2	Insert and remove drill bushings. Lock type head.	143.5
G-2	Pin part with locating pin. Lock type head.	146.4

SYNTHESIS

		TMU
K-1	Insert and remove loose symmetrical part Type I Fixture.	42.7
A	Insert loose symmetrical part Type I Fixture.	31.8
W	Remove loose symmetrical part Type I Fixture	10.9
K-2	Insert and remove close symmetrical part Type I Fixture.	53.3
B	Insert close symmetrical part Type I Fixture.	42.4
X	Remove close symmetrical part Type I Fixture	10.9
K-3	Insert and remove loose semi-symmetrical part Type I Fixture.	51.8
C	Insert loose semi-symmetrical part Type I Fixture.	40.9
Y	Remove loose semi-symmetrical part Type I Fixture	10.9
K-4	Insert and remove close semi-symmetrical part Type I Fixture.	65.9
D	Insert close semi-symmetrical part Type I Fixture.	51.5
Z	Remove close semi-symmetrical part Type I Fixture.	14.4
K-5	Insert and remove loose non-symmetrical part Type I Fixture.	53.1
E	Insert loose non-symmetrical part Type I Fixture.	42.2
A-1	Remove loose non-symmetrical part Type I Fixture.	10.9
K-6	Insert and remove close non-symmetrical part Type I Fixture.	67.2
F	Insert close non-symmetrical part Type I Fixture.	52.8
B-1	Remove close non-symmetrical part Type I Fixture.	14.4

K-7 Use Type I Fixture. Insert and remove part.

K-1	42.7
K-2	53.3
K-3	51.8
K-4	65.9
K-5	53.1
K-6	67.2

Average 55.6 Use .0006

K-8	Insert and remove tight fitting complex part Type I Fixture.	158.3
G	Insert tight fitting complex part.	107.2
C-1	Remove tight fitting complex part.	51.1

Use .002

K-9	Insert and remove part Type II Fixture (Small).	102.1
H	Insert part in Type II Fixture.	31.7
D-1	Remove part in Type II Fixture.	19.3
V-1	Remove and replace top plate.	51.1

Use .001

K-10	Insert and remove part in Type II Fixture (Large).	138.3
H-1	Insert part in Type II Fixture.	31.7
D-1	Remove part in Type II Fixture.	19.3
Y-1	Remove and replace top plate.	87.3

Use .0014

SYNTHESIS
(Contitued)

		TMU
K-11	Use Type II Fixture.	
	K-9 102.1	
	K-10 138.3	
	Average 120.2 Use .0012	
K-12	Insert and remove loose symmetrical part Type III Fixture.	122.4
I	Insert loose symmetrical part.	69.8
E-1	Remove loose symmetrical part.	52.6
K-13	Insert and remove close symmetrical part Type III Fixture.	136.5
J	Insert close symmetrical part.	80.4
F-1	Remove close symmetrical part.	56.1
K-14	Insert and remove loose semi-symmetrical part Type III Fixture.	125.9
L	Insert loose semi-symmetrical part.	73.3
G-1	Remove loose semi-symmetrical part.	52.6
K-15	Insert and remove close semi-symmetrical part Type III Fixture.	140.0
M	Insert close semi-symmetrical part.	83.9
H-1	Remove close semi-symmetrical part.	56.1
K-16	Insert and remove loose non-symmetrical part Type III Fixture.	127.2
N	Insert loose non-symmetrical part.	74.6
I-1	Remove loose non-symmetrical part.	52.6
K-17	Insert and remove close non-symmetrical part Type III Fixture.	141.3
O	Insert close non-symmetrical part.	85.2
J-1	Remove close non-symmetrical part.	56.1
K-18	Insert and remove loose symmetrical part Type III Fixture (Large).	131.9
P	Insert loose symmetrical part.	72.5
L-1	Remove loose symmetrical part.	59.4
K-19	Insert and remove close symmetrical part Type III Fixture (Large).	142.9
Q	Insert close symmetrical part.	76.0
M-1	Remove close symmetrical part.	66.9
K-20	Insert and remove loose semi-symmetrical part Type III Fixture (Large).	139.0
R	Insert loose semi-symmetrical part.	76.0
N-1	Remove loose semi-symmetrical part.	63.0
K-21	Insert and remove close semi-symmetrical part Type III Fixture (Large).	150.0
S	Insert close semi-symmetrical part.	83.1
O-1	Remove close semi-symmetrical part.	66.9
K-22	Insert and remove loose non-symmetrical part Type III Fixture (Large).	140.7
T	Insert loose non-symmetrical part.	77.3
P-1	Remove loose non-symmetrical part.	63.4

SYNTHESIS
(Continued)

		TMU
K-23	Insert and remove loose non-symmetrical part Type III Fixture(Large).	150.0
U	Insert close non-symmetrical part.	83.1
Q-1	Remove close non-symmetrical part.	66.9
K-24	Use Type III Fixture (Small).	
	K-12 122.4	
	K-13 136.5	
	K-14 125.9	
	K-15 140.0	
	K-16 127.0	
	K-17 141.0	
	Average 132.0 Use .0013	
K-25	Use Type III Fixture (Large).	
	K-18 131.9	
	K-19 142.0	
	K-20 139.0	
	K-21 150.0	
	K-22 140.7	
	K-23 150.0	
	Average 142.2 Use .0014	
K-26	Insert and remove part Type IV Fixture.	145.4
V	Insert part.	79.6
R-1	Remove part.	65.8
	Use .0015	
K-27		108.6
S-1	Open and close leaf with one-quarter turn thumb screw.	108.6
K-28		42.2
T-1	Open and close leaf gate, no fastening device.	42.2
K-29		237.7
U-1	Remove and replace top plate with two one-quarter turn thumb screws.	237.7
K-30		51.1
V-1	Remove and replace top plate on Type II Fixture and lock with pin (Small).	51.1
K-31		87.3
W-1	Remove and replace top plate with Type II Fixture and lock with pin.	87.3
K-32	Position and remove clamp (small) with bolt.	461.7
X-1	Position and remove.	32.4
Y-1	Tighten and loosen bolt.	429.3

SYNTHESIS
(Continued)

		TMU
K-33	Position and remove simple small clamp with Allen Head cap screw.	375.5
	X-1 Position clamp and remove.	32.4
	A-2 Tighten and loosen Allen screw.	343.1
K-34	Remove and replace nut on bolt.	71.2
	Y-1	71.2
K-35	Open and close quick acting clamp.	107.8
	Z-1	107.8
K-36	Tighten and loosen Allen Head cap screw or set screw.	343.1
	A-2	343.1
	Each additional.	298.0
K-37	Tighten and loosen bolt or nut with fingers one-half inch.	429.3
	B-2 Tighten and loosen bolt or nut with fingers.	429.3
	Each additional one-half inch.	72.0
K-38	Position and remove sliding clamp, spring pressure on bolt.	525.5
	C-2 Remove and replace clamp.	96.2
	K-37 Tighten and loosen nut.	429.3
K-39	Tighten and loosen knurled hand screw.	164.2
	D-2 Tighten and loosen knurled hand screw.	164.2
K-40	Tighten and loosen knurled hand screw with wrench or pliers.	255.7
	K-39 Tighten and loosen knurled hand screw hand tight.	164.2
	E-2 Tighten and loosen knurled hand screw with wrench.	91.5
K-41	Insert and remove drill bushing.	143.5
	F-2 Insert and remove drill bushing.	143.5
K-42	Pin part with locating pin.	146.4
	G-2 Pin part with locating pin.	146.4

TABLE OF CONSTANTS

Symbol	Description	TMU	Hours
K-1	Insert and remove loose symmetrical part Type I Fixture.	42.7	.0004
K-2	Insert and remove close symmetrical part Type I Fixture.	53.3	.0005
K-3	Insert and remove loose semi-symmetrical part Type I Fixture.	51.8	.0005
K-4	Insert and remove close semi-symmetrical part Type I Fixture.	65.9	.0007
K-5	Insert and remove loose non-symmetrical part Type I Fixture.	53.1	.0005
K-6	Insert and remove close non-symmetrical part Type I Fixture.	67.2	.0007

TABLE OF CONSTANTS
(Continued)

Symbol	Description	TMU	Hours
K-7	Use Type I Fixture - insert and remove.	55.6	.0006
K-8	Insert and remove tight fitting complex part Type I Fixture.	158.6	.0016
K-9	Insert and remove part Type II Fixture (Small).	102.1	.0010
K-10	Insert and remove part Type II Fixture (Large).	138.3	.0014
K-11	Insert and remove part Type II Fixture.	120.2	.0012
K-12	Insert and remove loose symmetrical part Type III Fixture.	122.4	.0012
K-13	Insert and remove close symmetrical part Type III Fixture.	136.5	.0014
K-14	Insert and remove loose semi-symmetrical part Type III Fixture.	125.9	.0013
K-15	Insert and remove close semi-symmetrical part Type III Fixture.	140.0	.0014
K-16	Insert and remove loose non-symmetrical part Type III Fixture.	127.2	.0013
K-17	Insert and remove close non-symmetrical part Type III Fixture.	141.3	.0014
K-18	Insert and remove loose symmetrical part Type III Fixture (Large).	131.9	.0013
K-19	Insert and remove close symmetrical part Type III Fixture (Large).	142.9	.0014
K-20	Insert and remove loose semi-symmetrical part Type III Fixture (Large).	139.0	.0014
K-21	Insert and remove close semi-symmetrical part Type III Fixture (Large).	150.0	.0015
K-22	Insert and remove loose non-symmetrical part Type III Fixture (Large).	140.7	.0014
K-23	Insert and remove close non-symmetrical part Type III Fixture.	150.0	.0015
K-24	Use Type III Fixture (Small) - average time.	132.0	.0013
K-25	Use Type III Fixture (Large) - average time.	142.2	.0014
K-26	Use Type IV Fixture.	145.4	.0015
K-27	Open and close leaf with one-quarter turn thumb screw.	108.6	.0011
K-28	Open and close leaf gate, no fastening device.	42.2	.0004
K-29	Remove and replace top plate with two one-quarter thumb screws.	237.7	.0024
K-30	Remove and replace top plate Type II Fixture and lock with pin (small).	51.1	.0005
K-31	Remove and replace top plate on Type II Fixture (Large) and lock with pin (large).	87.3	.0009
K-32	Position and remove clamp (small) with bolt.	461.7	.0046
K-33	Position and remove clamp (small) with Allen cap screw.	375.5	.0038
K-34	Remove and replace nut on bolt.	71.2	.0007
K-35	Open and close quick acting clamp.	107.8	.0011
K-36	Tighten and loosen Allen Head cap screw.	343.1	.0034
	Each additional.	298.0	.0030
K-37	Tighten and loosen bolt one-half inch.	429.3	.0043
	Each additional one-half inch.	72.0	.0007
K-38	Remove and replace sliding clamps.	525.5	.0053
K-39	Tighten and loosen knurled hand screw (hand tight).	164.2	.0016
K-40	Tighten and loosen knurled hand screw with wrench.	255.7	.0026
K-41	Insert and remove drill bushing.	143.5	.0014
K-42	Pin part with locating pin.	146.4	.0015

METHODS ANALYSIS CHART

Description-Left Hand	No.	L.H. TMU	R.H.	No.	Description-Right Hand
A Insert loose symmetrical part (Type I Fixture)					
		8.0	M4C		in Jig
Insert		5.6	P1SE		Position
		16.2	AP1		Seat
		2.0	RL1		
		31.8			
B Insert close fitting symmetrical part (Type I Fixture)					
		8.0	M4C		Move part to Jig
		16.2	P2SE		Position part
Insert		16.2	AP1		Seat part
		2.0	RL1		Release Part
		42.4			
C Insert loose fitting semi-symmetrical part (Type I Fixture)					
		8.0	M4C		in Jig
		9.1	P1SSE		Position
Insert		5.6	G2		
		16.2	AP1		Seat
		2.0	RL1		
		40.9			
D Position part in semi-symmetrical - tight fit (Type I Drill Jig)					
		8.0	M4C		Move into Jig
		19.7	P2SSE		Position part
Insert		5.6	G2		Regrasp
		16.2	AP1		Seat piece
		2.0	RL1		Release part
		51.5			
E Insert part in non-symmetrical Jig - loose fit (Type I Fixture)					
		8.0	M4C		Move part into Jig
		10.4	P1NSE		Position part
		5.6	G2		Regrasp
Insert		16.2	AP1		Seat piece firmly
		2.0	RL1		Release part
		42.2			
F Position part in non-symmetrical - tight fit (Type I Fixture)					
		8.0	M4C		Move into Jig
		21.0	P2NSE		Position part
Insert		5.6	G2		Regrasp
		16.2	AP1		Seat piece
		2.0	RL1		Release part
		52.8			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No. L.H.	TMU	R.H.	No.	Description-Right Hand
G Insert complex tight fitting part in Type I Fixture					
		8.0	M4C		Move into fixture
Insert		16.2	P2SE		Align part
		48.6	P3SD		Position to Jig
		32.4	AP1	2	Seat firmly
		2.0	RL1		Release
		107.2			
H Position semi-symmetrical part in Type II Fixture					
		8.0	M4C		Move part into Jig
		19.7	P2SSE		Position to Jig
Insert		2.0	MfA		Move to stop
		2.0	AL1		Release
		31.7			
I Insert symmetrical loose fitting part in small pump jig (Type III Fixture)					
Move part to Jig	M4C	8.0			Holding lever
Position part	P1SD	11.2			
Release part	RL1	2.0			
		10.6	M8B		Move lever to lock
Insert		32.4	AP1	2	Lock
Regrasp fixture	G2	5.6	(RL1)		Release
		69.8			
J Insert symmetrical tight fitting part in small pump jig (Type III Fixture)					
Move part to Jig	M4C	8.0			Holding lever
Position part	P2SD	21.8			
Release part	RL1	2.0			
Insert		10.6	M8B		Move lever to lock
		32.4	AP1	2	Lock
Regrasp fixture	G2	5.6	(RL1)		Release
		80.4			
L Insert semi-symmetrical part, loose fit, in pump Jig (Small Type III Fixture)					
					Holding lever
Move part to fixture	M4C	8.0			
Position part	P1SSD	14.7			
Release part	RL1	2.0			
Insert		10.6	M8B		Move lever to lock
		32.4	AP1	2	Lock
Regrasp fixture	G2	5.6	(RL1)		Release
		73.3			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H.	TMU	R.H.	No.	Description-Right Hand
M Insert semi-symmetrical tight fitting part in small pump jig (Type III Fixture)						
Move part to Jig		M4C	8.0			Holding lever
Position part		P2SSD	25.3			
Release part		RL1	2.0			
Insert			10.6	M8B		Move lever to lock
			32.4	AP1	2	Lock
Regrasp fixture		G2	5.6	(RL1)		Release
			83.9			
N Insert non-symmetrical loose fitting part from small pump jig (Type III Fixture)						
Move part to Jig		M4C	8.0			Holding lever
Position part		P1NSD	16.0			
Release part		RL1	2.0			
Insert			10.6	M8B		Move lever to lock
			32.4	AP1	2	Lock
Regrasp fixture		G2	5.6	(RL1)		Release
			74.6			
O Insert non-symmetrical tight fitting part from small pump jig (Type III Fixture)						
Move part to Jig		M4C	8.0			Holding lever
Position part		P2NSD	26.6			
Release		RL1	2.0			
Insert			10.6	M8B		Move lever to lock
			32.4	AP1	2	Lock
Regrasp			5.6	RL1		Release
			85.2			
P Insert loose symmetrical part in Large Type III Fixture						
						Holding lever
Move part into Jig		M4C	8.0			
Position		P1SE	5.6			
Insert		RL1	2.0			
			18.9	M16B5		Move lever lock
			32.4	AP1	2	Lock
Regrasp fixture		G2	5.6	(RL1)		Release
			72.5			
Q Insert tight symmetrical part in Large Type III Fixture						
						Holding lever
Move part into Jig		M4C	8.0			
Position		P2SE	9.1			
Release		RL1	2.0			
			18.9	M16B5		Move lever to lock
Insert			32.4	AP1	2	Lock
Regrasp fixture		G2	5.6	(RL1)		Release
			76.0			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H.	TMU	R.H.	No.	Description-Right Hand
G Insert complex tight fitting part in Type I Fixture						
			8.0	M4C		Move into fixture
Insert			16.2	P2SE		Align part
			48.6	P3SD		Position to Jig
			32.4	AP1	2	Seat firmly
			2.0	RL1		Release
			107.2			
H Position semi-symmetrical part in Type II Fixture						
			8.0	M4C		Move part into Jig
			19.7	P2SSE		Position to Jig
Insert			2.0	MfA		Move to stop
			2.0	AL1		Release
			31.7			
I Insert symmetrical loose fitting part in small pump jig (Type III Fixture)						
Move part to Jig		M4C	8.0			Holding lever
Position part		P1SD	11.2			
Release part		RL1	2.0			
			10.6	M8B		Move lever to lock
Insert			32.4	AP1	2	Lock
Regrasp fixture		G2	5.6	(RL1)		Release
			69.8			
J Insert symmetrical tight fitting part in small pump jig (Type III Fixture)						
Move part to Jig		M4C	8.0			Holding lever
Position part		P2SD	21.8			
Release part		RL1	2.0			
Insert			10.6	M8B		Move lever to lock
			32.4	AP1	2	Lock
Regrasp fixture		G2	5.6	(RL1)		Release
			80.4			
L Insert semi-symmetrical part, loose fit, in pump Jig (Small Type III Fixture)						
						Holding lever
Move part to fixture		M4C	8.0			
Position part		P1SSD	14.7			
Release part		RL1	2.0			
Insert			10.6	M8B		Move lever to lock
			32.4	AP1	2	Lock
Regrasp fixture		G2	5.6	(RL1)		Release
			73.3			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H.	TMU	R.H.	No.	Description-Right Hand
M Insert semi-symmetrical tight fitting part in small pump jig (Type III Fixture)						
Move part to Jig		M4C	8.0			Holding lever
Position part		P2SSD	25.3			
Release part		RL1	2.0			
Insert			10.6	M8B		Move lever to lock
			32.4	AP1	2	Lock
Regrasp fixture		G2	5.6	(RL1)		Release
			83.9			
N Insert non-symmetrical loose fitting part from small pump jig (Type III Fixture)						
Move part to Jig		M4C	8.0			Holding lever
Position part		P1NSD	16.0			
Release part		RL1	2.0			
Insert			10.6	M8B		Move lever to lock
			32.4	AP1	2	Lock
Regrasp fixture		G2	5.6	(RL1)		Release
			74.6			
O Insert non-symmetrical tight fitting part from small pump jig (Type III Fixture)						
Move part to Jig		M4C	8.0			Holding lever
Position part		P2NSD	26.6			
Release		RL1	2.0			
Insert			10.6	M8B		Move lever to lock
			32.4	AP1	2	Lock
Regrasp			5.6	RL1		Release
			85.2			
P Insert loose symmetrical part in Large Type III Fixture						
						Holding lever
Move part into Jig		M4C	8.0			
Position		P1SE	5.6			
Insert		RL1	2.0			
			18.9	M16B5		Move lever lock
			32.4	AP1	2	Lock
Regrasp fixture		G2	5.6	(RL1)		Release
			72.5			
Q Insert tight symmetrical part in Large Type III Fixture						
						Holding lever
Move part into Jig		M4C	8.0			
Position		P2SE	9.1			
Release		RL1	2.0			
			18.9	M16B5		Move lever to lock
Insert			32.4	AP1	2	Lock
Regrasp fixture		G2	5.6	(RL1)		Release
			76.0			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H.	TMU	R.H.	No.	Description-Right Hand
R Insert loose semi-symmetrical part from pump jig (Large Type III Fixture)						
						Holding lever
Move part into Jig		M4C	8.0			
Position		P1SSE	9.1			
Release		RL1	2.0			
Insert			18.9	M16B5		Move lever to lock
			32.4	AP1	2	Lock
Regrasp fixture		G2	5.6	(RL1)		Release handle
			76.0			
S Insert tight semi-symmetrical part from pump jig (Large Type III Fixture)						
						Holding lever
Move part to Jig		M4C	8.0			
Position		P2SSE	16.2			
Release		RL1	2.0			
Insert			18.9	M16B5		Move lever to lock
			32.4	AP1	2	Lock
Regrasp fixture		G2	5.6	(RL1)		Release handle
			83.1			
T Insert loose non-symmetrical part from pump jig (Large Type III Fixture)						
						Holding lever
Move part to Jig		M4C	8.0			
Position		P1NSE	10.4			
Release		RL1	2.0			
Insert			18.9	M16B5		Move lever to lock
			32.4	AP1	2	Lock
Regrasp fixture		G2	5.6	(RL1)		Release
			77.3			
U Insert tight non-symmetrical part in Large Type III Fixture						
						Holding lever
Move part into Jig		M4C	8.0			
Position		P2NSE	21.0			
Release		RL1	2.0			
Insert			18.9	M16B5		Move lever to lock
			32.4	AP1	2	Lock
Regrasp fixture		G2	5.6	(RL1)		Release
			87.9			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H.	TMU	R.H.	No.	Description-Right Hand
V Insert non-symmetrical part in drill plate (Type IV Fixture)						
	I		8.0	M4C		Move part to Jig
Regrasp	n	G2	5.6	G2		Regrasp
Position	s	P3NSE	47.8	P3NSE		Position
Seat part	e	AP1	16.2	AP1		Seat part
Release	r		2.0			Release
	t		79.6			
W Remove loose symmetrical part (Type I Fixture)						
Remove			4.0	D1E		_____
			6.9	M4B		_____
			10.9			
X Remove close fitting symmetrical part (Type I Fixture)						
Remove			4.0	D1E		_____
			6.9	M4B		_____
			10.9			
Y Remove loose fitting semi-symmetrical part (Type I Fixture)						
Remove			4.0	D1E		
			6.9	M4B		
			10.9			
Z Remove semi-symmetrical part, tight fit, (Type I Fixture)						
			7.5	D2E		Disengage part
Remove			6.9	M4B		Move out of Jig
			14.4			
A-1 Remove part in non-symmetrical jig, loose fit (Type I Fixture)						
			4.0	D1E		Disengage part
Remove			6.9	M4B		Move out of Jig
			10.9			
B-1 Remove part in non-symmetrical, tight fit, from Type I Fixture)						
Remove			7.5	D2E		Disengage part
			6.9	M4B		Move out of Jig
			14.4			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H.	TMU	R.H.	No.	Description-Right Hand
C-1 Remove complex tight fitting part from Type I Fixture						
			32.4	AP1	2	Loosen part
			11.8	D2D		Disengage part
Remove			6.9	M4B		Move out of fixture
			51.1			
D-1 Remove semi-symmetrical part from Type II Fixture						
			8.9	R6B		Reach for part
Remove			3.5	G1B		Grasp part
			6.9	M4B		Move part out of fixture
			19.3			
E-1 Remove symmetrical loose part from Small Type III Fixture						
			12.9	R12B		Reach for lever
			2.0	G1A		Grasp lever
Remove			16.2	AP1		Break loose
			10.6	M8B		Move lever up
Disengage part		D1E	4.0			
Move out of fixture		M4B	6.9			
			52.6			
F-1 Remove symmetrical tight part from Type III Fixture (Small)						
			12.9	R12B		Reach for lever
			2.0	G1A		Grasp lever
Remove			16.2	AP1		Break loose
			10.6	M8B		Move lever up
Disengage part		D2E	7.5			
Move out of fixture		M4B	6.9			
			56.1			
G-1 Remove semi-symmetrical part, loose fitting, from Small Type III Fixture						
			12.9	R12B		Reach for lever
			2.0	G1A		Grasp lever
Remove			16.2	AP1		Break loose
			10.6	M8B		Move lever up
Disengage part		D1E	4.0			
Move out of fixture			6.9			
			52.6			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L. H. TMU	R.H.	No.	Description-Right Hand
H-1 Remove semi-symmetrical tight part from Small Type III Fixture					
		12.9	R12B		Reach for lever
		2.0	G1A		Grasp lever
Remove		16.2	AP1		Break loose
		10.6	M8B		Move lever up
Disengage part	D2E	7.5			
Move out of fixture	M4B	6.9			
		56.1			
I-1 Remove non-symmetrical loose part from Small Type III Fixture					
		12.9	R12B		Reach for lever
		2.0	G1A		Grasp lever
Remove		16.2	AP1		Break loose
		10.6	M8B		Move lever up
Disengage part	D1E	4.0			
Move out of Jig	M4B	6.9			
		52.6			
J-1 Remove non-symmetrical tight fitting part from Small Type III Fixture					
		12.9	R12B		Reach for lever
		2.0	G1A		Grasp lever
Remove		16.2	AP1		Break loose
		10.6	M8B		Move lever up
Disengage part	D2E	7.5			
Move out of Jig	M4B	6.9			
		56.1			
L-1 Remove loose symmetrical part from Large Type III Fixture					
Holding fixture		12.9	R12B		Reach for lever
		2.0	G1A		Grasp lever
Remove		16.2	AP1		Break tension
		21.4	M16B12		
Move out of fixture	M4B	6.9			
		59.4			
M-1 Remove right symmetrical part from Large Type III Fixture					
Holding fixture		12.9	R12B		Reach for lever
		2.0	G1A		Grasp lever
Remove		16.2	AP1		Break Tension
		21.4	M16B12		Move lever up
Disengage part	D2E	7.5			
Move out of fixture	M4B	6.9			
		66.9			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No. L.H.	TMU	R.H.	No.	Description-Right Hand
N-1 Remove loose semi-symmetrical part from Large Type III Fixture					
Holding fixture		12.9	R12B		Reach for lever
		2.0	G1A		Grasp lever
Remove		16.2	AP1		Break tension
		21.4	M16B12		Move lever up
Disengage part	D1E	4.0			
Move out of fixture	M4B	6.9			
		63.4			
O-1 Remove tight semi-symmetrical part from Large Type III Fixture					
Holding fixture		12.9	R12B		Reach for lever
		2.0	G1A		Grasp lever
		16.2	AP1		Break tension
Remove		21.4	M16B12		Move lever up
Disengage part	D2E	7.5			
Move out of fixture	M4B	6.9			
		66.9			
P-1 Remove loose non-symmetrical part from Large Type III Fixture					
Holding fixture		12.9	R12B		Reach for lever
		2.0	G1A		Grasp lever
Remove		16.2	AP1		Break tension
		21.4	M16B12		Move lever up
Disengage part	D1E	4.0			
Move out of fixture	M4B	6.9			
		63.4			
Q-1 Remove right non-symmetrical part from Large Type III Fixture					
		12.9	R12B		Reach for lever
		2.0	G1A		Grasp lever
Remove		16.2	AP1		Break tension
		21.4	M16B12		Move lever up
Disengage part	D2E	7.5			
Move out of fixture	M4B	6.9			
		66.9			
R-1 Remove non-symmetrical part from Type IV Fixture					
		8.6	R6B		Reach for screw driver
		2.	G1A		Grasp screw driver
		8.9	M6B		Move screw driver to piece
			G2		Regrasp
Remove		19.7	P2SSE		Position screw driver
		16.2	AP1		Apply pressure
Grasp Piece	G1B	3.5			
Move piece	M4B	6.9			Move screw driver
		65.8			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H. TMU	R.H.	No.	Description-Right Hand
S-1 Open and close leaf on small box drill jig with one-quarter turn thumb screw (Type I Fixture)					
Close leaf to stop	M6A	8.1			
		4.0	R2B		Reach for one-quarter turn thumb screw
		2.0	G1A		Grasp one-quarter turn thumb screw
Open		2.0	MfB		Move thumb screw one-quarter turn
		16.2	AP1		Lock one-quarter turn thumb screw
Release leaf	RL1	2.0	RL1		Release one-quarter turn thumb screw
Reach to leaf	R12B	12.9	R12B		Reach for thumb screw
Grasp leaf	G1A	2.0	G1A		Grasp thumb screw
		16.2	AP1		Loosen one-quarter turn thumb screw
Close		19.7	P2SSE		Position one-quarter turn thumb screw
		2.0	RL1		Release one-quarter turn thumb screw
Move cover up	M6B	8.9	R6B		Reach for body
Push to lock up	AP2	10.6	G1A		Grasp body of Jig
Release leaf	RL1	2.0	RL1		Release Jig
		108.6			
T-1 Close leaf gate in fastening device - closed to a stop and open					
		8.6	R6B		Reach for gate leaf
		2.0	G1A		Grasp
		8.1	M6A		Close
		2.0	RL1		Release
		8.6	R6B		Reach for gate leaf
		2.0	G1A		Grasp
		8.9	M6B		Open
		2.0	RL1		Release
		42.2			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H.	TMU	R.H.	No.	Description-Right Hand
U-1 Place and remove top plate from box jig with two one-quarter turn thumb screws						
Reach for top plate		R12B	12.9	R12B		Reach for top plate
Grasp top plate		G1B	3.5	G1B		Grasp top plate
Move to fixture		M12C	15.2	M12C		Move to fixture
Position		P2SSE	19.7			
			19.7	P2SSE		Position
Release		RL1	2.0	RL1		Release
Reach for thumb screw		R8B	10.1	R8B		Reach for thumb screw
Grasp		G1A	2.0	G1A		Grasp
Tighten		MfB	2.0	MfB		Tighten
	2	AP1	32.4	AP1	2	
		RL1	2.0	RL1		
Machine Operation						
Reach for thumb screw		R12B	12.9	R12B		Reach for thumb screw
Grasp		G1A	2.0	G1A		Grasp
	2	AP1	32.4	AP1	2	
Position		P2SSE	19.7			
			19.7	P2SSE		Position
		RL1	2.0	RL1		
Reach for top plate		R8B	10.1	R8B		Reach for top plate
Grasp		G1A	2.0	G1A		Grasp
Lay aside		M12B	13.4	M12B		Lay aside
Release		RL1	2.0	RL1		Release
			237.7			
V-1 Position and remove top plate on sandwich type drill jig and lock with pin (Type II Fixture - Small)						
			10.1	R8B		Reach for top plate
			2.0	G1A		Grasp top plate
			11.8	M8C		Move to Jig
			16.2	P2SE		Position to Jig
			5.6	P1SE		
			2.0	RL1		Release
			5.3	R3B		Reach to lock pin
			6.7	M3C		Move to Jig
			16.2	P2SE		Position locating pin
			3.6	M2A		Move in
			16.2	AP1		Seat pin firmly
			2.0	RL1		Release
			97.7			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H. TMU	R.H.	No.	Description-Right Hand
		Machine Operation			
		12.9	R12B		Reach for locating pin
		2.0	G1A		Grasp locating pin
		2.9	M1B		Move up
		7.5	D2E		Disengage
		5.7	M3B		Lay aside
Disengage top plate	D2E	7.5	RL1		Release
Lay aside top plate	M8B	10.6			
Release	RL1	2.0			
		51.1			
W-1 Put top plate on Type II drill fixture and lock with pin (medium and large) and remove					
Reach for top plate	R12B	12.9	R12B		Reach for top plate
Grasp top plate	G1A	2.0	G1A		Grasp top plate
Move to bottom plate	M12C	15.2	M12C		Move to bottom plate
Position to Jig	P2SE	16.2	P2SE		Position to Jig
Hold	P1SE	5.6	P1SE		
		2.0	RL1		Release plate
		8.6	R6B		Reach for pin
		2.0	G1A		Grasp pin
		10.3	M6C		Move pin to plate
		16.2	P2SE		Position pin
		3.6	M2A		Move pin in
		16.2	AP1		Seat pin firmly
		2.0	RL1		Release
		112.8			
		Machine Operation			
		12.9	R12B		Reach for locking pin
		2.0	G1A		Grasp pin
		16.2	AP1		Loosen pin
		4.6	M2B		Move pin up
		7.5	D2E		Disengage
		10.6	M8B		Lay pin aside
Release	RL1	2.0	RL1		Release
Same		10.1	R8B		Reach for top plate
as		2.0	G1A		Grasp top plate
right		4.0	D1E		Disengage
hand		13.4	M12B		Lay plate aside
		2.0			Release
		87.3			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H. TMU	R.H.	No.	Description-Right Hand
X-1 Position dog clamps, simple type clamp, and turn to a stop					
		6.4	R4B		To clamp
		2.0	G1A		
On		4.6	M2B		Clear work
		3.5	T45S		Position
		2.0	RL1		
		6.4	R4B		
Off		2.0	G1A		
		3.5	T45S		Clear work
		2.0	RL1		
		32.4			
	Add	5.6			
Y-1 Remove and replace nut on bolt					
		12.9	R12B		To nut
		2.0	G1A		
On		15.2	M12C		To bolt
		19.7	P2SSE		
		2.0	MfB		Start
		2.0	RL1		
		2.0	MfB		
		13.4	M12B		Aside
		2.0			
		71.2			
Z-1 Tighten and loosen quick acting clamp, lever, or handle					
		8.6	R6B		To handle
		2.0	G1A		
Close		8.9	M6B		
		32.4	AP1	2	Close
		2.0	RL1		
		8.6	R6B		To handle
		2.0	G1A		
Open		32.4	AP1	2	Open
		8.9	M6B		
		2.0	RL1		
		107.8			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H. TMU	R.H.	No.	Description-Right Hand
A-2 Tighten and loosen Allen Head set screws					
		12.9	R12B		To wrench
		3.5	G1B		
		15.2	M12C		To screw
		19.7	P2SSE		
		5.6	G2		New grip
		32.4	AP1	2	Break tension
		5.6	G2		
		8.9	M6B		Turn screw
		7.5	D2E		
		10.3	M6C		To new position
		19.7	P2SSE		
		8.9	M6B		Turn screw
		7.5	D2E		
		13.4	M12B		Aside
		2.0	RL1		
		12.9	R12B		To wrench
		3.5	G1B		
		15.2	M12C		To screw
		19.7	P2SSE		
		8.9	M6B		Turn screw
		5.6	G2		
		7.5	D2E		
		10.3	M6C		To new position
		19.7	P2SSE		
		8.9	M6B		Turn
		32.4	AP1	2	Tighten
		5.6	G2		
		7.5	D2E		
		8.9	M12B		Aside
		2.0	RL1		
		343.1			

Each Additional Allen Head Set Screw

343.1

	(2	R12B	25.8)
	(2	G1B	7.0)
Minus	(1	M12C	10.3)
	(1	RL1	2.0)
	(		45.1)

298.

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H. TMU	R.H.	No.	Description-Right Hand
B-2 Tighten or loosen bolt or nut; run down with fingers one-half inch					
		6.4	R4B		To nut
		2.0	G1A		
		17.5	T45S	5	Spin down with fingers
		28.0	G2	5	
		12.9	R12B		To wrench
		3.5	G1B		
		15.2	M12C		To nut
		39.4	P2SSE	2	
		13.8	M4B	2	Tighten
		15.0	D2E	2	
		8.9	M6B		To new position
		32.4	AP1	2	
		13.4	M12B		Wrench aside
		2.0	RL1		
		12.9	R12B		To wrench
		3.5	G1B		
		15.2	M12C		To bolt or nut
		39.4	P2SSE	2	
		32.4	AP1	2	
		13.8	M4B	2	
		8.9	M6B		New position
		15.0	D2E	2	
		13.4	M12B		Wrench aside
		2.0	RL1		
		12.9	R12B		To nut
		2.0	G1A		
		17.5	T45S	5	Spin up
		28.0	G2	5	
		2.0	RL1		
		429.3			
Each additional ½"					
			G1A	8	
			MfB	8	Turn up or down
			RL1	8	With fingers
			RfB	8	
			72.0		

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H. TMU	R.H.	No.	Description-Right Hand
C-2 Position and remove sliding clamp spring pressure on bolt					
		12.9	R12B		To clamp
		2.0	G1A		
		16.9	AP1		
		6.9	M4B		On work
		16.2	P2SE		
		2.0	RL1		
		12.9	R12B		To clamp
		2.0	G1A		
		16.2	AP1		
		6.9	M4B		Off work
		2.0	RL1		
		96.2			
D-2 Tighten and loosen knurled head hand or thumb screw hand tight					
		8.9	R6B		To hand screw
		2.0	G1A		
		23.0	M2B	5	Preliminary tighten
		28.0	G2	5	
		16.2	AP1		Tighten
		2.0	RL1		
		12.9	R12B		To hand screw
		2.0	G1A		
		16.2	AP1		Loosen
		23.0	M2B	5	Spin out
		28.0	G2	5	
		2.0	RL1		
		164.2			
E-2 Tighten or loosen above slotted hand screw with bar or wrench					
		12.9	R12B		To bar or wrench
		3.5	G1B		
		15.2	M12C		To screw
		19.7	P2SSE		
		16.2	AP1		
		4.6	M2B		
		4.0	D1E		
		13.4	M12B		
		2.0	RL1		
		91.5			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H. TMU	R.H.	No.	Description-Right Hand
F-2 Insert and remove drill bushings, lock type, from liners 0 - 1" in length					
		12.9	R12B		Reach to bushing
Hold Jig		2.0	G1A		Grasp bushing
		15.2	M12C		Move to Jig
		16.2	P2SE		Position to liner
		21.0	P2NSE		Position to lock
		2.0	MfA		Move to lock
		16.2	AP1		Lock with pressure
		2.0	RL1		Release bushing
		12.9	R12B		Reach to bushing
		2.0	G1A		Grasp bushing
		16.2	AP1		Unlock
		2.0	MfA		
		7.5	D2E		Disengage
		13.4	M12B		Lay aside
		2.0	RL1		Release
Sub-Total		143.5			
G-2 Pin part with locating pin, lock type head; insert and remove (from 0 - 1" in length).					
		12.9	R12B		Reach for locating pin
Hold Jig		2.0	G1A		Grasp pin
		15.2	M12C		Move to Jig
		16.2	P2SE		Position pin
		16.2	AP1		Push pin in
		21.0	P2NSE		Position pin lock
		2.0	MfA		Lock pin
		2.0	RL1		Release
		12.9	R12B		Reach to locating pin
		2.0	G1A		Grasp pin
		16.2	AP1		Loosen pin
		2.0	MfA		Turn to unlock
		2.9	M1B		Remove pin
		7.5	D2E		Disengage pin
		13.4	M12B		Lay pin aside
			G2		
		2.0	RL1		Release bushing
		146.4			

OPERATING TIME FORMULA

MILLING FIXTURES

	Fixtures		
K1	Type I	Simple	.0007
K2		Complex	.0013
K3	Type II	Simple	.0009
K5		Complex	.0011
K6	Type III	Simple	.0010
K7		Complex	.0024
K8	Use vise		.0024
K9	Universal chuck on dividing head		.0035
K10	Hardinge index head		.0012
	For parts demanding extreme care, add .0010		

	Locating	
K22	Spring loaded index pin, center or plug	.0005
K23	Threaded locating pin	.0036
K24	Leaf locator (revolving type) w/index pin	.0014
K25	Locating pin (removable)	.0016
K26	Locating pin (stationary)	.0012
K27	Feeler gage	.0011
K28	Position and remove washer	.0011

	Clamping	
K4	Lock and release movable center - Type II Fixture	.0009
K11	Quick acting clamp	.0011
K12	Sliding clamp, spring pressure on bolt	.0053
K13	Socket head set screws	.0034
K14	Each additional set screw	.0030
K15	Knurled head, hand, or thumb screw	.0016
K16	Knurled head screw w/slot (Wrench tightening)	.0025
K17	Remove and replace nut or bolt	.0070
K18	Tighten and loosen bolt or nut to one-half inch	.0043
K29	Each additional one-half inch of bolt or nut	.0007
K19	Place and remove solid clamp on part	.0070
K20	Position and remove "C" washer	.0007
K21	Use shim stock behind clamp or part	.0012
K30	Seat part w/plastic hammer	.0009
K31	Hammer vise handle w/plastic hammer	.0013

DATA SHEET INSTRUCTIONS

Values given on the Data Sheet include both insertion and removal of parts and tightening and loosening of clamping or locating devices. Time values given on the Data Sheet are expressed in levelled time without allowances.

1. Determine type of fixture or holding device employed.

   Determine class of fixture (Simple or Complex). Select required time.

2. Determine subsequent positioning necessary to operate fixture, such as using threaded, stationary, or removable locating pins. Refer to Data Sheet, locate desired element, and select time value. If more than one is used, multiply the time value by number required.

3. Determine the method of clamping part in fixture. This will only apply to Types I, II, and III fixtures. The vise, collet, and universal chuck times are total values which include securing the part. Due to the variety of clamping methods used to operate the three types of fixtures, all methods have to be considered individually. Refer to data sheet and locate desired method. If more than one device is used, the time value will have to be multiplied by the number of occurrences:

   EXAMPLE: A fixture has three sliding clamps:

   .0053 hour per each clamp x 3 equals .0159 hour - Total Time for Clamping Part.

When to Use Time for Parts Demanding Extreme Care

- When the nature of the part is such that it may spring or bend out of shape or blueprint tolerance when clamps are tightened.

- When care must be exercised in positioning part in fixture to prevent hitting part against fixture, damaging finished surfaces, or bending part.

- When blueprint tolerances are interrelated and less than .002 inches, use the time allowed for positioning part with extreme care.

When to Use (K30) - Seat Part W/Plastic Hammer

IF the dimensional tolerance is .005 inches or less when using a vise as a fixture.

IF the nature of the part is such that there is bind in seating over tight fitting plugs or pins or if part must be seated in a close-fitting cavity.

When to Use (K31) - Hammer Vise Handle W/Plastic Hammer

IF the part must be held tightly in the vise to prevent slippage during heavy cuts.

IF the part is large.

IF the nature of the part is such that the clamping surface is small in relation to the size of the part.

FORMULA REPORT

APPLICATION: All fixtures used on 2H, 2HL, and 08 Vertical and Horizontal Milling Machines.

OPERATION: Operating time for milling fixtures.

ALLOWED TIME: Each piece - See Work Sheet. All time values in Data Sheet are levelled times, without allowances.

APPLICATION

This formula contains time values for Positioning, Locating, and Clamping piece parts in the three basic type milling fixtures used on milling machines in Departments 635-3 and 635-4.

The formula also contains time values for the Locating, Positioning, and Clamping of parts in a Vise, Hardinge Index Head, or Universal Chuck on a dividing head.

The data pertains to fixtures normally used on Milwaukee 2H, 2HL, and Cincinnati 08 milling machines.

The time values expressed in this formula are representative of conditions in effect as of April 1956. Any change in operating conditions, equipment, or methods may require the time values to be revised.

TYPE I

MILLING FIXTURE

PLATE TYPE FIXTURE

This fixture primarily consists of a base plate which is bolted to the table. It may have a box-like appearance. Parts are located in many different manners: against solid or adjustable blocks; solid or adjustable buttons and pins; removable pins, threaded pins, spring loaded support pins; or over a plug in a cavity.

Parts may be clamped by quick acting clamps; hand, thumb, or knurled screws; threaded locating pins; socket head cap or set screws; plain clamps; sliding clamps; spring clamps; or bolts.

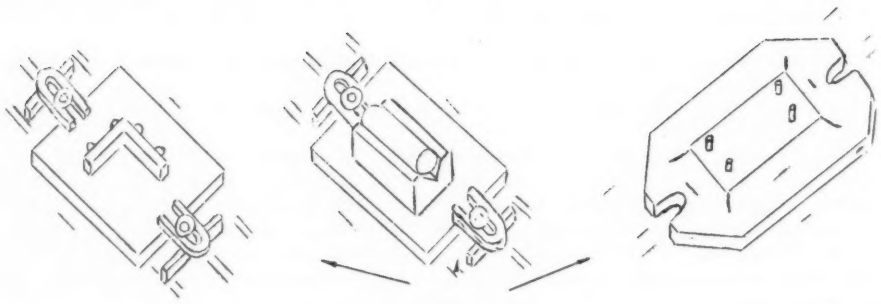
The difference between a simple and complex fixture exists primarily in the positioning involved.

In a complex fixture, the part is usually inserted into a cavity or recess. Positioning is usually difficult and involves positioning the part to several fixed pins, or the piece part has to be prepositioned before entering the jig. Locating surfaces are obstructed by clamping arrangement or are hard to get at.

In a simple fixture, the part is easily located with a minimum amount of effort, usually requires only one position, and clamps and locating surfaces are readily accessible.

FEATURE

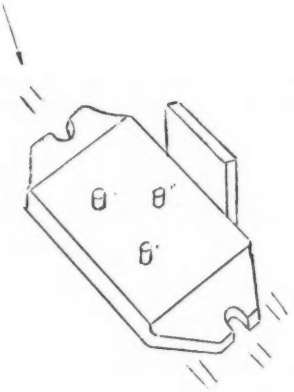
TYPE I MILLING FIXTURE

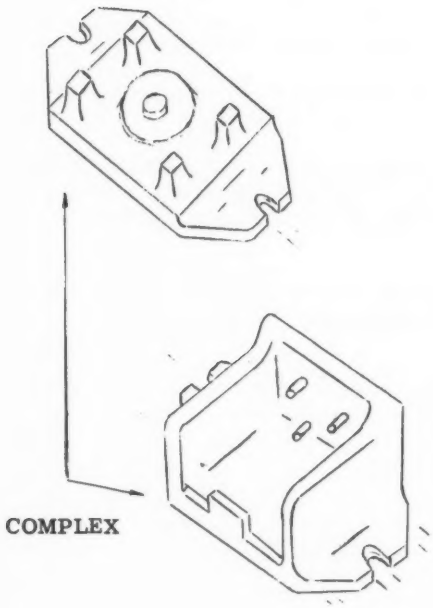


SIMPLE

These sketches are intended to be used only as a guide in selecting fixture types. They portray identifying characteristics of a Type I Milling Fixture. Type I Milling Fixtures will vary with the purpose and nature of the work.

The securing of piece part has been omitted in the sketches because of the many different methods used. These methods or devices are listed on the Data Sheet.





COMPLEX

Simplicity of positioning of a piece part is the keynote in differentiating a simple fixture from a complex fixture.

If the locating surfaces are easily accessible and part easily inserted, it is a simple fixture.

If locating surfaces are recessed into a cavity and hands are restricted when inserting part, it is a complex fixture.

TYPE II

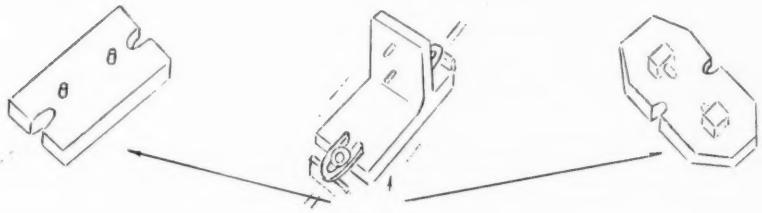
MILLING FIXTURE

CENTER TYPE FIXTURE

Center type fixtures are those in which the work is located between centers or between plugs on the Outer Diameter or Inner Diameter. The locators or centers may be of the quick-acting or hand screw type.

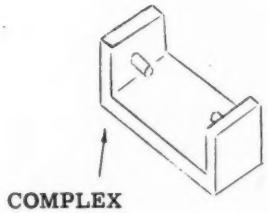
In the more complex fixture of this type, a positioning pin or locating block is used in addition to the two centers or plugs. In determining the time value for this type of fixture, care must be taken to observe the exact manner in which the part is located and particularly the method used in securing the part.

TYPICAL TYPE II MILLING FIXTURE

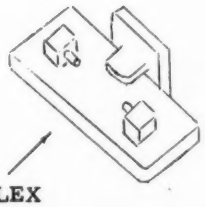


SIMPLE

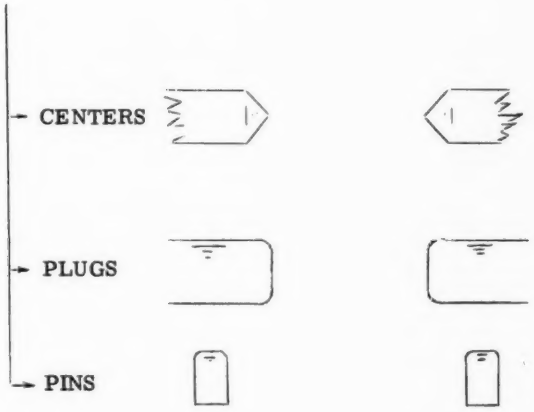
To qualify for a Type II Fixture, primary location of part must be accomplished by one of the three methods sketched below:



COMPLEX



COMPLEX



Simple, as used for purpose of definition, means the position involves only the inserting of the piece part between centers, plugs, or pins.

Complex is the inserting of the piece part between centers, plugs, or pins, and some additional location point, such as a stop or fixed locating pin. Complex also applies when the locating surfaces are not easily accessible, such as insertion into a cavity where hands are restricted.

These sketches are intended to be used only as a guide in selecting fixture types. They portray identifying characteristics of a Type II Milling Fixture. Type II Milling Fixtures will vary with the purpose and nature of the work. The securing of piece part has been omitted in the sketches because of the many different methods used. These methods or devices are listed on the Data Sheet.

TYPE III

MILLING FIXTURE

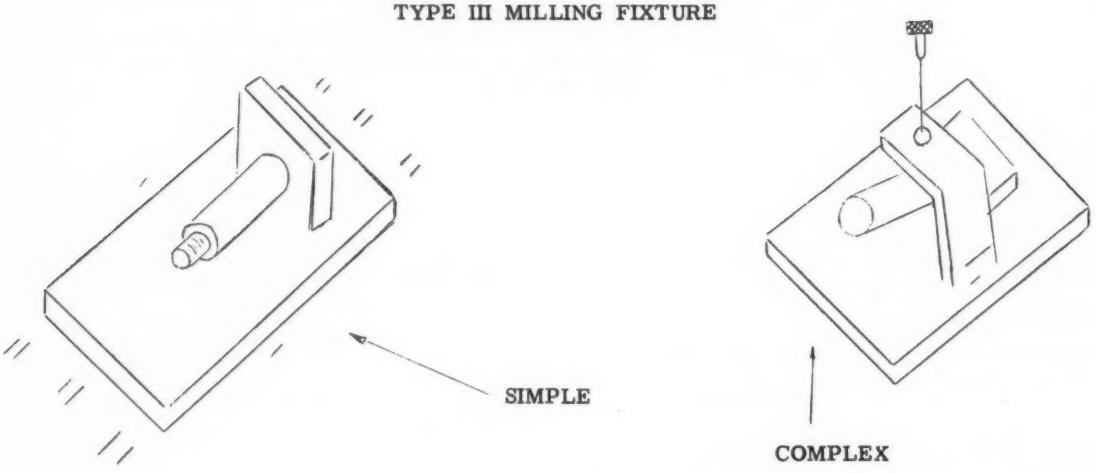
PILOT OR STUD TYPE FIXTURE

Pilot or stud type fixtures are those fixtures in which the part is positioned on a stud, pilot, or arbor of some type. The pilot, stud, or arbor must be part of the fixture. This formula is not intended to cover instances where the piece part is positioned on an arbor or stud, and then the stud or arbor is located between centers or in some other manner.

The simple position in this type of fixture usually involves a short move on a pilot or stud with no subsequent positioning required. The fit is close, but the part is positioned easily.

In the complex positioning, the fit on the arbor, stud, or pilot is generally tight or difficult to perform. The part may bind several times. Operator may have to apply pressure and regrasp part to complete positioning. Subsequent positioning is generally required.

TYPE III MILLING FIXTURE



Arbor or Stud Type

A simple Type III Milling Fixture is one in which the locating surfaces are easily accessible, part fits on arbor or stud easily, and requires little, if any, orientation after positioning on arbor.

A complex Type III is one in which the locating surfaces are not easily accessible, hands are restricted, and part difficult to handle.

If part is fragile or requires care in handling, use time for complex fixture.

These sketches are intended to be used only as a guide in selecting fixture types. They portray identifying characteristics of a Type III Milling Fixture. Type III Milling Fixtures will vary with the purpose and nature of the work. The securing of piece part has been omitted in the sketches because of the many different methods used. These methods or devices are listed on the Data Sheet.

TABLE OF CONSTANTS

Symbol	Description	Decimal Hours
K1	Type I Fixture (Simple)	.0007
K2	Type I Fixture (Complex)	.0013
K3	Type II Fixture (Simple)	.0009
K4	Lock and release movable center, Type II Fixture	.0009
K5	Type II Fixture (Complex)	.0011
K6	Type III Fixture (Simple)	.0010
K7	Type III Fixture (Complex)	.0024
K8	Use vise	.0024
K9	Universal chuck on dividing head	.0035
K10	Hardinge index head	.0012
K11	Quick acting clamp	.0011
K12	Sliding clamp, spring pressure on bolt	.0053
K13	Socket head set screws	.0034
K14	Each additional set screw	.0030
K15	Knurled head, hand, or thumb screw	.0016
K16	Knurled head screw with slot (wrench tightening)	.0025
K17	Remove and replace nut or bolt	.0070
K18	Tighten or loosen bolt or nut to one-half inch	.0043
K19	Place and remove solid clamp on part	.0070
K20	Position and remove "C" washer	.0007
K21	Use shim stock behind clamp or part	.0012
K22	Spring loaded index pin or center or plug	.0005
K23	Threaded locating pin	.0036
K24	Leaf locator (revolving type) with index pin	.0014
K25	Locating pin (removable)	.0016
K26	Locating pin (stationary)	.0012
K27	Feeler gage	.0011
K28	Position and remove washer	.0011
K29	Each additional one-half inch of bolt or nut	.0007
K30	Seat part with plastic hammer	.0009
K31	Hammer vise handle with plastic hammer	.0013

TABLE OF ELEMENTS

A	Position and remove piece part in Type I Fixture (Simple).	67.2
B	Position and remove piece part in Type I Fixture (Complex).	129.8
C	Insert and remove part from Type II Fixture (Simple Part).	93.2
D	Lock and release movable center, Type II Fixture.	86.6
E	Insert and remove part from Type II Fixture (Complex Location).	109.4
F	Position piece part in Type III Fixture (Simple Location).	95.6
G	Position piece part in Type III Fixture (Complex Location).	242.0
H	Seat part in vise with plastic hammer.	89.4
I	Insert and remove piece in vise.	66.1
J	Insert and remove piece in three jaw universal chuck on dividing head.	258.7
L	Remove and replace handle on vise.	68.0
M	Hammer vise handle to tighten with plastic hammer.	127.9
N	Open and close vise by hand.	109.4
O	Tighten and loosen quick acting clamp (lever or handle).	107.8
P	Position and remove sliding clamp - spring pressure on bolt.	96.2
Q	Tighten and loosen socket head set screws.	343.1
R	Each additional socket head set screw.	298.
S	Tighten and loosen knurled head hand or thumb screw hand tight.	164.2
T	Tighten or loosen slotted hand screw with bar or wrench.	86.9
U	Tighten and loosen bolt or nut - run down with fingers one-half inch.	429.3
V	Remove and replace nut or bolt.	70.7
W	Place and remove solid clamp.	82.0
X	Position and remove "C" washer.	64.3
Y	Insert and remove spring loaded index pin (center or plug).	47.6
Z	Insert and remove threaded locating pin.	358.3
A-1	Position and remove leaf locator (revolving type) with index pin.	144.9
B-1	Insert and remove locating pin (removable type).	147.9
C-1	Insert and remove locating pin (stationary type).	110.7
D-1	Insert and remove shim stock from behind clamps or part (per occurrence).	111.5
E-1	Use feeler gage (per occurrence).	107.1
F-1	Position and remove washer on bolt.	113.9
G-1	Loosen or tighten nut on bolt (turn per one-half inch).	72.0
H-1	Insert and remove piece in Hardinge index head collet.	115.5

SYNTHESIS

			TMU
K1	A	Position and remove piece part in Type I Fixture (Simple Part)	67.2
K2	B	Position and remove piece part in Type I Fixture (Complex Part)	129.8
K3	C	Insert and remove part in Type II Fixture (Simple)	93.2
K4	D	Lock and release movable center, Type II Fixture	86.6
K5	E	Insert and remove part from Type II Fixture (Complex Location)	109.4
K6	F	Position piece part in Type III Fixture (Simple Location)	95.6
K7	G	Position piece part in Type III Fixture (Complex Location)	242.0
K8		Use vise	243.5
	I	Insert and remove piece part	66.1
	L	Position handle on vise	68.0
	N	Open and close vise by hand	109.4
K9		Use three jaw universal chuck on die head	348.1
	J	Insert and remove part	258.7
	H	Seat part w/plastic hammer	89.4
K10		Use Hardinge index head	115.5
	H-1	Insert and remove part	115.5
K11	O	Tighten and loosen quick acting clamp	107.8
K12		Sliding clamp, spring pressure on bolt	525.5
	P	Position and remove clamp	96.2
	U	Tighten and loosen bolt	429.3
K13		Socket head set screws	343.1
	Q	Tighten and loosen	343.1
K14		Socket head set screws	298.
	R	Each additional set screw	298.
K15		Knurled head hand or thumb screw	164.2
	S	Tighten and loosen (hand tight)	164.2
K16		Knurled head screw w/slot	251.1
	S	Tighten and loosen (hand tight)	164.2
	T	Use bar on slotted screw	86.9
K17	V	Remove and replace nut or bolt	70.7

SYNTHESIS
(Continued)

			TMU
K18	U	Tighten and loosen bolt or nut (run down w/fingers one-half inch)	429.3
K19		Place and remove solid clamp on part	695.9
	W	Place and remove clamp	82.0
	V	Remove and replace nut on bolt	70.7
	U	Tighten and loosen	429.3
	F-1	Place washer on bolt	113.9
K20	X	Position and remove "C" washer	64.3
K21		Use shim stock	111.5
	D-1	Use behind clamps or part (per occurrence)	111.5
K22		Spring loaded index pin, center or plug	47.6
	Y	Insert and remove	47.6
K23		Threaded locating pin	358.3
	Z	Insert and remove	358.3
K24		Leaf locator (revolving type) w/index pin	144.9
	A-1	Position and remove	144.9
K25		Locating pin (removable type)	159.3
	B-1	Insert and remove	159.3
K26		Locating pin (stationary in fixture)	122.1
	C-1	Insert and remove	122.1
K27		Feeler gage	113.9
	E-1	Use per occurrence	113.9
K28	F-1	Position and remove washer on bolt	113.9
K29	G-1	Each additional one-half inch of bolt or nut	72.0
K30	H	Seat part w/plastic hammer	89.4
K31	M	Hammer vise handle w/plastic hammer	127.9

METHODS ANALYSIS CHART

Description-Left Hand	No. L.H.	TMU	R.H.	No.	Description-Right Hand
A Position and remove piece part in Type I Fixture (Simple)					
		8.0	M4C		To jig
		21.0	P2NSE		
		5.6	G2		Hold in place
		16.2	AP1		
		2.0	RL1		
		7.5	D2E		Out of jig
		6.9	M4B		
		67.2			
B Position and remove piece part in Type I Fixture (Complex)					
		8.0	M4C		To jig
		5.6	G2		
		21.0	P2NSE		In jig
Insert		10.3	M6C		
		21.0	P2NSE		
		16.2	AP1		Seat part
		2.0	RL1		
		7.5	D2E		
Remove		10.3	M6C		Out of jig
		21.0	P2NSE		
		6.9	M4B		
		129.8			
C Insert and remove part from Type II Fixture with Inner Diameter or Outer Diameter close fitting plugs as locators (Simple Position)					
		8.0	M4C		In fixture
		16.2	P2SE		To first plug
Insert		16.2	AP1		Move to seat
		16.2	P2SE		To second plug
		2.0	RL1		
		4.0	MfB	2	Shake part
Remove		16.2	AP1		Pull
		7.5	D2E		
		6.9	M4B		Out of fixture
		93.2			

On this type of fixture, the only center encountered was of the hand screw type. This time will be found in the Table of Elements.

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H. TMU	R.H.	No.	Description-Right Hand
D Lock and release movable center, Type II Fixture					
		8.6	R6B		Reach for handle
		2.0	G1A		Grasp handle
Lock		8.9	M6B		Move handle
		5.6	G2		Regrasp
		16.2	AP1		
		2.0	RL1		
Release		8.6	R6B		To handle
		2.0	G1A		
		16.2	AP1		Break loose
		5.6	G2		
		8.9	M6B		Move
		2.0	RL1		
		86.6			
E Insert and remove part from Type II Fixture (Complex Location) with Inner Diameter or Outer Diameter plugs as locators					
Either hand or both		8.0	M4C		In fixture
		16.2	P2SE		To first plug
Insert		16.2	AP1		Seat in place
		16.2	P2SE		To second plug
		16.2	P2SE		To additional locator
		2.0	RL1		
		4.0	MfB	2	Shake part
		16.2	AP1		Pull
Remove		7.5	D2E		
		6.9	M4B		Out of fixture
		109.4			
If part weighs over two and one-half pounds, both hands are used to position part. Time remains same.					
F Position piece part in Type III Fixture (Simple Position)					
		8.0	M4C		To fixture
		16.2	P2SE		
Insert		5.6	G2		
		8.1	M6A		Seat part
		16.2	AP1		
		2.0	RL1		
		16.2	AP1		Break loose
Remove		8.9	M6B		Move along arbor
		7.5	D2A		
		6.9	M4B		Out of fixture
		95.6			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H. TMU	R.H.	No.	Description-Right Hand
G Position piece part in Type III Fixture (Complex Positioning - Part Difficult To Handle)					
		8.0	M4C		To fixture
		26.6	P2NSD		
		16.8	G2	3	Move along arbor
Insert		48.6	AP1	3	
		11.3	M10A		
		16.2	AP1		Seat part
		2.0	RL1		
		16.2	AP1		Break loose
Remove		12.2	M10B		
		16.8	G2	3	Off arbor stud
		48.6	AP1	3	
		11.8	D2D		
		6.9	M4B		
		242.0			
H Seat part in vise with plastic hammer					
		15.8	R16B		To hammer
		2.0	G1A	1	Grasp hammer
		10.6	M8B	1	Move hammer to vise
		5.6	P1SE	1	Position over work
		27.6	M4B	4	Hammer stroke
		27.6	M4A	4	Hammer stroke
		89.4			
I Insert and remove piece in vise (either or both hands)					
		8.0	M4C		In vise
		21.0	P2NSE		
Insert		8.0	MfB	4	Seat part
		16.2	AP1		
		2.0	RL1		
Remove		4.0	D1E		Out of vise
		6.9	M4B		
		66.1			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H.	TMU	R.H.	No.	Description-Right Hand
J Insert and remove piece in three jaw universal chuck on dividing head						
To wrench		R16B	15.8			
		G1A	2.0			
To chuck		M16B	15.8	R16A		To wrench
			2.0	G1A		Grasp shank
Regrasp wrench		G2	5.6			
To chuck		M4C	8.0	M4C		To chuck
		P2SSE	19.7	P2SSE		
			2.0	RL1		
			6.1	R4A		To handle
			2.0	G1A		
Loosen		AP1	16.2	AP1		Loosen
		M2B	4.6	M2B		
		G2	5.6	RL1		
Turn wrench		T120S	8.6	R6B		To piece part
			2.0	G1A		
			4.0	D1E		
			6.9	M4B		Move out of chuck
			8.0	M4C		To chuck
			16.2	P2SE		
			16.2	AP1		Seat part
			8.0	MfB	4	
Turn wrench to tighten		T120S	6.8			
			8.6	R6B		To handle
			2.0	G1A		
Regrasp handle		G2	5.6			
Tighten		M2B	4.6	M2B		Tighten
	2	AP1	32.4	AP1	2	
Regrasp handle		G2	5.6			
			2.0	RL1		Release wrench
Wrench aside		M16B	15.8			
		RL1	2.0			
			260.7			
L Position handle on vise						
			2.0	G1A		
			10.3	M6C		
On			19.7	P2SSE		
			2.0	RL1		
Off			2.0	G1A		
			10.3	M6C		
			19.7	P2SSE		
			2.0	RL1		
			68.0			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H. TMU	R.H.	No.	Description-Right Hand
M Hammer vise handle to tighten with plastic hammer					
		15.8	R16B		To hammer
		2.0	G1A		
		18.7	M16C		To vise handle
		5.6	P1SE		
		32.4	M6A	4	Hammer
		35.6	M6B	4	
		15.8	M16B		Hammer aside
		2.0	RL1		
		127.9			
N Open and close vise by hand					
		15.8	R16B		Reach to handle
		2.0	G1A		Grasp handle
Open		32.4	AP1	2	Initial opening of vise
		10.6	M8B		Move handle to open
		2.0	RL1		Release
		15.8	R16B		Reach to handle
		2.0	G1A		Grasp handle
Close		10.6	M8B		Move handle to close
		16.2	AP1		Final tighten
		2.0	RL1		Release handle
		109.4			
O Tighten and loosen quick acting clamp (lever or handle)					
		8.6	R6B		To handle
		2.0	G1A		
Close		8.9	M6B		
		32.4	AP1	2	Close
		2.	RL1		
		8.6	R6B		To handle
		2.0	G1A		
Open		32.4	AP1	2	Open
		8.9	M6B		
		2.0	RL1		
		107.8			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H. TMU	R.H.	No.	Description-Right Hand
P Position and remove sliding clamp - spring pressure on bolt - care exercised					
		12.9	R12B		To clamp
		2.0	G1A		
		16.2	AP1		
		6.9	M4B		On work
		16.2	P2SE		
		2.0	RL1		
		12.9	R12B		To clamp
		2.0	G1A		
		16.2	AP1		Off work
		6.9	M4B		
		2.0	RL1		
		96.2			
Q Tighten and loosen socket head set screws					
		12.9	R12B		Reach for wrench
		3.5	G1B		Grasp wrench
		15.2	M12C		Move wrench to screw
		19.7	P2SSE		Position wrench
		5.6	G2		Regrasp wrench
		32.4	AP1	2	Break loose
		5.6	G2		Regrasp wrench
		8.9	M6B		Turn screw
Tighten		7.5	D2E		Disengage wrench
		10.3	M6C		Move to new position
		19.7	P2SSE		Position
		8.9	M6B		Turn screw
		7.5	D2E		Disengage wrench
		13.4	M12B		Lay aside
		2.0	RL1		Release
		12.9	R12B		Reach to wrench
		3.5	G1B		Grasp wrench
		15.2	M12C		Move to set screw
Loosen		19.7	P2SSE		Position
		8.9	M6B		Turn screw
		5.6	G2		Regrasp wrench
		7.5	D2E		Disengage wrench
		10.3	M6C		Move to new position
		19.7	P2SSE		Position
		10.3	M6B		Turn
		32.4	AP1	2	Tighten
		5.6	G2		Regrasp wrench
		7.5	D2E		Disengage wrench
		8.9	M12B		Lay aside
		2.0	RL1		Release wrench
		3431.			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H.	TMU	R.H.	No.	Description-Right Hand
R Each additional socket head set screw						
			343.1			
Time for	(2	R12B	25.8)			
obtaining	(2	G1B	7.0)			
Minus	(1	M12C	10.3)			
Lay aside tool	(1	RL1	2.0)			
	(		45.1) - 298.			
S Tighten and loosen knurled head hand or thumb screw hand tight						
			8.9	R6B		To hand screw
			2.0	G1A		
			23.0	M2B	5	Preliminary tighten
Tighten			28.0	G2	5	
			16.2	AP1		Tighten
			2.0	RL1		
			12.9	R12B		To hand screw
			2.0	G1A		
			16.2	AP1		Loosen
Loosen			23.0	M2B	5	Spin Out
			28.0	G2	5	
			2.0	RL1		
			164.2			
T Tighten or loosen slotted hand screw with bar or wrench						
			12.9	R12B		To bar
			3.5	G1B		
			15.2	M12C		To screw
			19.7	P2SSE		
			16.2	AP1		Tighten
			4.0	D1E		
			13.4	M12B		Aside
			2.0	RL1		
			86.9	X2		

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H.	TMU	R.H.	No.	Description-Right Hand
U Tighten and loosen bolt or nut, run down with fingers one-half inch						
			6.4	R4B		To nut
			2.0	G1A		
			17.5	T45S	5	Spin down with fingers
			28.0	G2	5	
			12.9	R12B		To wrench
			3.5	G1B		
			15.2	M12C		To nut
			39.4	P2SSE	2	
			13.8	M4B	2	Tighten
			15.0	D2E	2	
			8.9	M6B		To new position
			32.4	AP1	2	
			13.4	M12B		Wrench aside
			2.0	RL1		
			12.9	R12B		To wrench
			3.5	G1B		
			15.2	M12C		To bolt or nut
			39.4	P2SSE	2	
			32.4	AP1	2	Break tension
			13.8	M4B	2	
			8.9	M6B		New Position
			15.0	D2E	2	
			13.4	M12B		Wrench aside
			2.0	RL1		
			12.9	R12B		To nut
			2.0	G1A		
			17.5	T45S	5	Spin up
			28.0	G2	5	
			2.0	RL1		
			429.3			
V Remove and replace nut on bolt						
			12.9	R12B		To nut
			2.0	G1A		
On			15.2	M12C		To bolt
			16.2	P2SE		
			3.5	T45S		Start
			2.0	RL1		
			3.5	T45S		Off
Off			13.4	M12B		Lay aside
			2.0	RL1		
			70.7			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H.	TMU	R.H.	No.	Description-Right Hand
W Remove and replace solid clamp on part						
			15.8	R16B		In clamp
			2.0	G1A		
			18.7	M16C		To bolt
On			5.6	P1SE		On bolt
			3.6	M2A		
			5.6	G2		
			2.0	MfB		
			2.0	RL1		
			6.9	R4B		To clamp
Off			2.0	G1A		
			15.8	M16B		Off clamp and aside
			2.0	RL1		
			82.0			
X Position and remove "C" washer from bolt						
			15.8	R16B		To washer
			3.5	G1B		
			5.6	P1SE		On bolt
			5.6	G2		
			3.6	M2A		
			2.0	RL1		
			6.9	R4B		To bolt
			3.5	G1B		
			15.8	M16B		Lay aside
			2.0	RL1		
			64.3			
Y Insert and remove spring loaded index pin (center or plug)						
			12.9	R12B		To handle
			2.0	G1A		
Remove			6.9	M6B		Move out
			2.0	RL1		
Either hand						
			12.9	R12B		To handle
Insert			2.0	G1A		
			6.9	M6B		Move in
			2.0	RL1		
			47.6			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H.	TMU	R.H.	No.	Description-Right Hand
Z Insert and remove threaded locating pin						
			12.9	R16B		To pin
			2.0	G1A		
			15.2	M12C		To fixture
			16.2	P2SE		
			5.7	M3B		Move in to work
			16.2	P2SE		Position work
			42.0	T45S	12	Turn in
			67.2	G2	12	
			16.2	AP1		Seat
			2.0	RL1		
			12.9	R12B		To pin
			2.0	G1A		
			16.2	AP1		Break tension
			42.0	T45S	12	
			67.2	G2	12	
			7.5	D2E		
			12.9	M12B		Aside
			2.0	RL1		
			358.3			
A-1 Position and remove leaf locator (revolving type) with index pin						
To leaf		R12B	12.9			
		G1B	3.5			
Turn leaf to open side of fixture		M6B	8.9			
		G2	5.6			
Move to index pin		M4A	6.1			
Push leaf down		AP1	16.2	(P2SE)		position part
		M1A	2.5			
Turn leaf back to position		M6B	8.9			
		G2	5.6			
To index pin		M4A	6.1			
		RL1	2.0			
To leaf		R12B	12.9			
		G1B	3.5			
Turn leaf to open side of fixture		M6B	8.9			
		G2	5.6			
Move to index pin		M4A	6.1			
Pull leaf up		AP1	16.2			
		M1A	2.5			
Turn leaf away to insert new part		M6B	8.9			
		RL1	2.0			
			144.9			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H. TMU	R.H.	No.	Description-Right Hand
B-1 Pin part with removable pin. Insert and remove "0" - one inch long. Pin is removed each time operation is performed.					
		12.9	R12B		To pin
		2.0	G1A		
In		15.2	M12C		To jig
		16.2	P2SE		
		2.9	M1B		Move in
Rotate part to position	P2SE	16.2			
		4.6	M2B		Move in and seat
		16.2	AP1		
		2.0	RL1		
		12.9	R12B		To pin
		2.0	G1A		
		16.2	AP1		Move out of jig
		5.7	M3B		
		7.5	D2E		Disengage
		13.4	M12B		Aside
		2.0	RL1		
		147.9			
For pins over one inch long, add 11.4 to above value.					
C-1 Pin part with locating pin; insert and remove (from "0" - one inch in length), Pin stationary in jig.					
		12.9	R12B		To pin
		2.0	G1A		
Insert		16.2	AP1		Move pin in
		4.6	M2B		
Rotate part to position	P2SE	16.2			
		2.9	M1B		Engage pin
		16.2	AP1		
	RL1	2.0	RL1		
		12.9	R12B		To pin
		2.0	G1A		
		16.2	AP1		Move out
		4.6	M2B		
		2.0	RL1		
		110.7			
For pins over one inch long, add 11.4 to above value.					

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H.	TMU	R.H.	No.	Description-Right Hand
D-1 Insert and remove shim stock from behind clamps or part. (Per occurrence)						
			12.9	R12B		To shims
			3.5	G1B		
			15.2	M12C		To work
			25.3	P2SSD		
			4.6	M2B		
Hold in place		AP1	16.2			
			12.9	R12B		To shim
			3.5	G1B		
Raise work or lift clamp		MfB	2.0			
			13.4	M12B		Aside
			2.0	RL1		
			111.5			
E-1 Use feeler gage. (Per occurrence)						
			15.8	R16B		To feeler gage
			3.5	G1B		
			18.7	M16C		To work
			25.3	P2SSD		
			26.0	M2C	5	Check
			15.8	M16B		Lay aside
			2.0	RL1		
			107.1			
F-1 Position and remove washer on bolt						
			15.8	R16B		To washer
			3.5	G1B		
			2.0	MfB		
On			5.6	G2		
			18.7	M16C		To bolt
			16.2	P2SE		
			6.1	M4A		
			2.0	RL1		
			15.8	R16B		To bolt
			3.5	G1B		
Off			6.9	M4B		Off bolt
			15.8	M16B		Lay aside
			2.0	RL1		
			113.9			

METHODS ANALYSIS CHART
(Continued)

Description-Left Hand	No.	L.H. TMU	R.H.	No.	Description-Right Hand
G-1 Loosen or tighten nut or bolt, per one-half inch					
		16.0	G1A	8	Grasp
		16.0	MfB	8	Move
		16.0	RL1	8	Release
		16.0	RfB	8	Reach
		72.0			
H-1 Insert and remove piece in Hardinge index head collet					
To collet	M4C	8.0			
	P2SE	16.2			
Seat	MfA	2.0			
	MfB	2.0			
		5.7	M3B		Close collet
		5.6	G2		Regrasp
		32.4	AP1	2	Tighten
		2.0	RL1		
		6.4	R4B		To lever
Grasp part	G1A	2.0	G1A		
		16.2	AP1		Open collet
		6.1	M4A		
Out of collet	D1E	4.0			
	M4B	6.9			
		115.5			

FEATURE

OPERATING TIME FORMULA

TURRET LATHE FIXTURES

APPLICATION: All fixtures normally used on Warner and Swasey No. 3, 4, and 5 and Jones and Lamson No. 7A and 7B.

OPERATION: Operating time for turret lathe fixtures.

ALLOWED TIME: Each piece - see Work Sheet.

APPLICATION

This formula contains time values for positioning, locating and clamping piece parts in the four basic type Turret Lathe fixtures used in the Dept. 633-3 and 636-1. The data pertains to fixtures normally used on Warner and Swasey No. 3, 4, and 5 and Jones and Lamson No. 5, 7A and 7B.

The time values expressed in this formula are representative of conditions in effect as of June 1956.

Any change in operating conditions, equipment or methods may require the time values to be revised.

TYPE I

LATHE FIXTURES

These fixtures consist of a round plate bolted to a face plate or directly to the lathe spindle. This plate has a box-like affair welded to it which contains locators and parts clamping devices. Parts may be located in the fixture in many different manners; to solid or adjustable stops, buttons or pins; over a plug or in a cavity. This type of fixture is usually indexed with an index plate.

Parts are usually clamped by plain spring operated clamps, tightened with a hex nut; screw operated clamps with hand knob; cam operated clamps with screws, cradle clamps, or leaf-type clamps with rockers.

The difference between a simple and a complex Type I fixture is primarily in the positioning involved. In a complex fixture, positioning is usually difficult and involves fitting the part to several locators or stops.

Locating surfaces may be obstructed and clamping arrangements difficult to operate.

On simple fixtures, parts are easily located, usually require only one position, and clamping devices are unobstructed and easy to manipulate.

TYPE II

LATHE FIXTURES

This fixture consists of a right angle type locating device attached to a face plate.

Parts are located by inserting into a Vee, or against solid locators, plugs or bores that are paralleled with the plate, or against solid stops. This type of fixture may also have an index plate.

Parts are clamped in the same manner as Type I fixtures.

The difference between a simple and complex Type II fixture is determined in the same manner as for Type I fixtures.

TYPE III

LATHE FIXTURES

PLUG OR BORE TYPE

Plug or bore type fixtures are composed of a circular plate with either a locating plug set into it or a bore machined into the center. This plate is bolted onto the machine spindle. Part clamps are usually placed around the perimeter of the mounting plate.

Occasionally in the plug type fixture clamping is performed by threading a nut onto the end of the plug.

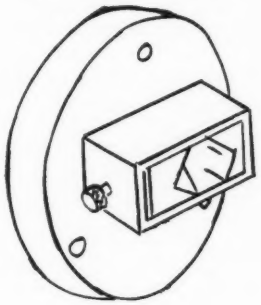
TYPE IV

LATHE FIXTURES

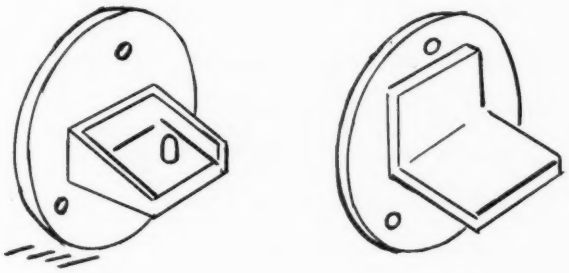
THREADED ARBORS

Type IV fixtures consist primarily of a round plate bolted to a face plate or directly to the spindle. A threaded arbor is either machined in the plate or pressed into a bored hole and pinned in place. Some arbors have no clamping devices, on these the piece part merely locks against a shoulder. In others, there will be a bolt and washer in the end of the arbor.

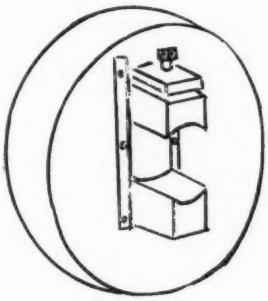
Type I Box Fixture



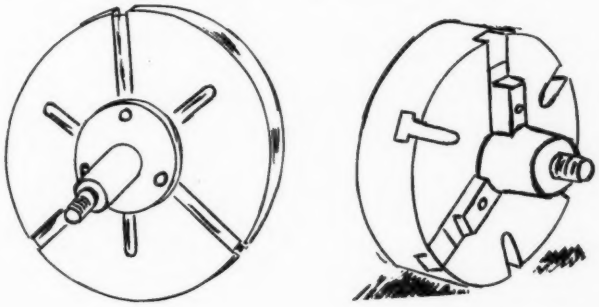
Type II Right Angle



Type III Bore or Plug Fixtures



Type IV Threaded



These sketches are intended to be used only as a guide in selecting fixture types. They portray identifying characteristics of the four basic types. These fixtures will vary with the purpose and nature of the work. The securing of the piece part has been omitted in the sketches because of the many different methods used. These methods and/or devices are listed on the Data Sheet.

DATA SHEET - LATHE FIXTURES

FIXTURES

K1	Type I	Simple	.0006
K2	Type I	Complex	.0014
K3	Type II	Simple	.0013
K4	Type II	Complex	.0020
K5	Type III		.0016
K6	Type IV		.0022
	For parts demanding extreme care, add		.0010

LOCATING

K7	Index Type I and Type II	.0013
K15	Use spring loaded index pin, center or plug	.0006
K16	Use threaded locating pin	.0036
K17	Use removable locating pin	.0015
K18	Use stationary locating pin	.0011
K20	Use Feeler Gage	.0011

CLAMPING

K8	Quick acting clamp, lever or handle	.0011
K9	Sliding clamp, spring pressure or bolt	.0053
K10	Tighten and loosen Allen Head set screws	.0034
	Each additional set screw	.0030
K11	Knurled Head hand or thumb screw	.0025
K12	Remove and replace nut or bolt	.0007
K13	Tighten and loosen bolt or nut	.0086
	Each additional 1/2 inch	.0007
K14	Use solid clamp	.0069
K19	Use shim stock behind part or clamp	.0011
K21	Use "C" washer	.0006
K22	Seat part with plastic hammer	.0010
K23	Use washer	.0011

DATA SHEET INSTRUCTIONS

Time value given on the data sheet include both insertion and removal of parts and tightening and loosening of clamping or locating devices. Time values given on the data sheet are expressed in leveled time without allowances.

1. (a) Determine type of fixture employed.
   (b) Determine class of fixture (Simple or Complex).
   (c) Select required time from the data sheet for selected type and class of fixture.

2. Determine subsequent positioning necessary to operate the fixture, such as using threaded, stationary, or removable locating pins. Refer to data sheet, locate desired element and select time value. If more than one is used, multiply the time values by the number required.

3. Determine the method of clamping part in fixture. Due to the variety of clamping methods used to operate the three types of fixtures, all methods will have to be considered individually. Refer to data sheet, locate desired method; if more than one device is used, the time value must be multiplied by the number of occurrence.

EXAMPLE: A fixture has 3 sliding clamps: .0053 hr. per clamp x 3 = .0159 hours. Total time for clamping part.

When to Use Time for Parts Demanding Extreme Care

When the nature of the part is such that it may spring or bend out of shape or blueprint tolerance when clamps are tightened.

When care must be exercised in positioning part in fixture to prevent hitting part against fixture, damaging finished surfaces, or bending part.

When blueprint tolerances are interrelated and less than .002, use the time allowed for positioning part with extreme care.

When to Use (K22) Seat Part with Plastic Hammer

If the nature of the part is such that there is bind in seating the part over tight fitting plugs or pins or if part must be seated in a close fitting cavity.

SYNTHESIS

			Hours
K1	A	Position and remove piece part in Type I Lathe fixture - Simple Positioning	.0006
K2	B	Position and remove piece part in Type I Lathe fixture - Complex Positioning	.0014
K3	C	Position and remove piece part in Type II fixture - Simple Positioning	.0013
K4	D	Position and remove piece part in Type II fixture - Complex Positioning	.0020
K5	E	Position and remove part in Type III fixture with I.D. or O.D. close fitting plugs or bores as locators	.0016
K6	F	Position and remove part in Type IV fixture, threaded plug	.0022
K7	G	Index Type I and II Lathe fixtures	.0013
K8	H	Tighten and loosen Quick Acting clamp, lever or handle	.0011
K9		Sliding clamp - spring pressure on bolt	.0053
	I	Position and remove clamp	.0010
	O	Tighten and loosen bolt	.0043
K10	J	Tighten and loosen Allen Head set screw	.0034
K11		Knurled Head Hand or Thumb Screw	.0025
	L	Tighten and loosen - Hand tight	.0016
	M	Tighten with pliers or wrench	.0009
K12	N	Remove and replace nut or bolt	.0007
K13	O	Tighten or loosen bolt or nut; run down with fingers one-half inch each additional 1/2 inch	.0043
K14		Place and remove solid clamp on part	.0069
	P	Place and remove clamp	.0008
	O	Place and remove washer on bolt	.0011
	N	Place and remove nut or bolt	.0007
	K13	Tighten and loosen nut or bolt (to 1/2")	.0043
K15	R	Insert and remove spring loaded index pin, center or plug	.0006
K16	S	Insert and remove threaded locating pin	.0036
K17	T	Insert and remove locating pin (removable type)	.0015
K18	U	Insert and remove locating pin (stationary type)	.0011
K19	V	Insert and remove shim stock from behind clamps or part per occurrence	.0011
K20	W	Use Feeler gage per occurrence	.0011
K21	X	Position and remove "C" washer or bolt	.0006
K22	Y	Use plastic hammer per occurrence	.0010
K23	Q	Position and remove washer or bolt	.0011

LIST OF ELEMENTS

A	Position and remove piece part in Type I lathe fixture - Simple position
B	Position and remove piece part in Type I fixture - Complex positioning
C	Position and remove piece part in Type II fixture - Simple positioning
D	Position and remove piece part in Type II fixture - Complex positioning
E	Position and remove part in Type III fixture with I.D. or O.D. close fitting plugs or bores as locators
F	Position and remove part in Type IV fixture, threaded plug
G.	Index Type I and II - Lathe fixtures
H	Tighten or loosen quick acting clamp, lever or handle
I	Position and remove sliding clamp, spring pressure or bolt
J	Tighten and loosen Allen Head set screw
L	Tighten and loosen Knurled Head hand or thumb screw - hand tight
M	Tighten or loosen hand or thumb screw with pliers or wrench
N	Remove and replace nut or bolt
O	Tighten or loosen bolt or nut; run down with fingers one-half inch
P	Place and remove solid clamp or part
Q	Position and remove washer or part
R	Insert and remove spring loaded index pin, center or plug
S	Insert and remove threaded locating pin
T	Insert and remove locating pin (removable type)
U	Insert and remove locating pin (stationary type)
V	Insert and remove shim stock from behind clamps or part - per occurrence
W	Use Feeler gage per occurrence
X	Position and remove "C" washer or bolt
Y	Use plastic hammer per occurrence

METHODS ANALYSIS CHART

Description - Left Hand	No.	L.H.	TMU	R.H.	No.	Description - Right Hand
			Position and Remove Piece Part in Type I Lathe Fixture - Simple Positioning			
A			8.0	M4C		To Jig
			21.0	P2SNE		
			16.2	AP1		
			2.0	RL1		
			7.5	D2E		Out of Jig
			6.9	M4B		
			61.6			
			Position and Remove Piece Part in Type I Complex Positioning			
B			8.0	M4C		To Jig
			5.6	G2		
	Insert		26.6	P2NSD		In Jig
			8.0	M4C		
			21.0	P2NSE		
			34.4	AP1	2	Seat Part
			2.0	RL1		
			11.8	D2D		
			8.0	M4C		Out of Jig
	Remove		10.4	P1NSE		
			6.9	M4B		
			140.7			
			Position and Remove Piece Part in Type II Fixture - Simple Positioning			
C			8.0	M4C		To Fixture
			16.2	P2SE		
	Insert		6.7	M3C		
			5.6	G2		Locate Piece
			26.6	P2NSD		
			32.4	AP1	2	
			2.0	RL1		
	Remove		2.0	MFB		
			16.2	AP1		
			11.8	D2D		
			6.9	M4B		
			134.4			

METHODS ANALYSIS CHART
(Continued)

Description - Left Hand	No.	L.H. TMU	R.H.	No.	Description - Right Hand
Position and Remove Piece Part in Type II Fixture Complex Positioning					
D		8.0	M4C		To Fixture
		48.6	P3SD		
Insert		6.7	M3C		
		11.2	G2	2	Locate Piece
		26.6	P2NSD		
		34.4	AP1	2	
		2.0	RL1		
		2.0	MFB		
Remove		5.6	G2		
		2.0	MFB		
		32.4	AP1	2	
		11.8	D2D		
		6.9	M4B		
		196.2			
Position and Remove Part from Type III Fixture with I.D. or O.D. Close Fitting Plugs or Bores as Locators					
E		8.0	M4C		To Fixture
		53.4	P3NSD		
Insert		8.0	M4C		Seat Part
		32.4	AP1	2	
		2.0	RL1		
		4.0	MFB		Move Part
Remove		32.4	AP1	2	Pull
		11.8	D2D		
		6.9	M4B		Out of Fixture
		158.9			
If Plug or Bore is over 2" in length add 3.4 for each inch in length					
Position and Remove Part Type IV Fixture Threaded Plug					
F		8.0	M4C	1	To Fixture
		21.8	P2SD	1	
Insert		20.0	MFB	10	
		20.0	RL1	10	Thread or Plug
		20.0	G1A	10	
		16.2	P2SE	1	
		16.2	AP1	1	
		2.0	RL1	1	
		16.2	AP1		Break Loose
		5.6	G2		
		20.0	MFB	10	
Remove		20.0	RL1	10	
		20.0	G1A	10	
		5.6	G2		
		6.9	M4B		
		218.5			

METHODS ANALYSIS CHART
(Continued)

Description - Left Hand	No.	L.H. TMU	R.H.	No.	Description - Right Hand
		Index Type I and II Lathe Fixtures			
G		15.8	R16B		
		2.0	G1A		
		16.2	AP1		
		6.9	M4B		
		7.5	D2E		
		5.6	G2		
		18.2	M2OB		
		19.7	P2SE		
		32.4	AP1	2	
		2.0	RL1		
		126.3			
		Tighten and Loosen Quick Acting Clamp, Lever or Handle			
H		107.8			
		Element Z-1 - Formula F-1			
		Position and Remove Sliding Clamp, Spring Pressure or Bolt			
I		96.2			
		Element C-2 - Formula F-1			
		Tighten and Loosen Allen Head Set Screw			
J		343.1			
		Each Additional Allen Head Set Screw			
		298.0			
		Element A-2 - Formula F-1			
		Tighten and Loosen Knurled Head Hand or Thumb Screw Hand Tight			
L		164.2			
		Element D-2 - Formula F-1			
		Tighten or Loosen Hand or Thumb Screw With Pliers or Wrench			
M		91.5			
		Element E-2 Formula F-1			
		Remove and Replace Nut or Bolt			
N		71.2			
		Element Y-1 - Formula F-1			

METHODS ANALYSIS CHART
(Continued)

Description - Left Hand	No.	L.H.	TMU	R.H.	No.	Description - Right Hand
Tighten or Loosen Bolt or Nut; Run Down With Fingers One-Half Inch						
O			429.3			
Each Additional 1/2"						
			72.0			
Element B-2 - Formula F-1						
Place and Remove Solid Clamp on Part						
P			82.0			
Element W - Formula F-2						
Position and Remove Washer or Bolt						
Q			113.9			
Element F-1 - Formula F-2						
Insert and Remove Spring Loaded Index Pin, Center, or Plug						
R			15.8			R16B
	Insert		2.0			G1A
			2.0			MFB
			8.1			M6A
			2.0			RL1
	Either Hand Remove		15.8			R16B
			2.0			G1A
			16.2			AP1
			8.1			M6A
			2.0			RL1
			74.0			
Insert and Remove Threaded Locating Pin						
S			358.3			
Element Z - Formula F-2						
Insert and Remove Locating Pin (Removable Type)						
T			147.9			
Element B-1 - Formula F-2						
Insert and Remove Locating Pin (Stationary Type)						
U			110.7			
Element C-1 - Formula F-2						

METHODS ANALYSIS CHART
(Continued)

Description - Left Hand	No.	L.H. TMU	R.H.	No.	Description - Right Hand
		Insert and Remove Shim Stock from Behind Clamps or Part - Per Occurrence			
V		111.5			
		Element D-1 - Formula F-2			
		Use Feeler Gage Per Occurrence			
W		107.1			
		Element E-1 - Formula F-2			
		Position and Remove "C" Washer or Bolt			
X		64.3			
		Element X - Formula F-2			
		Use Plastic Hammer - Per Occurrence			
Y		96.5			
		Element J - Formula D-1			

TECHNICAL

EFFECT OF VISUAL REQUIREMENTS ON SIMULTANEOUS MOTIONS

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It is "Journal" policy to print the results of current research accomplished in the field of Predetermined Motion Times. "Journal" printing in no way constitutes Association acceptance or approval of information contained. Professor Stan Block, University of Minnesota, presented the following research report at an MTM Seminar in Chicago, Illinois, October, 1956:

The objective of this research was to compare simultaneous symmetrical hand-motion patterns with similar one-hand motion patterns and to determine how increased visual requirements caused by variations in the orientation of the objects being grasped and the relative location of the grasping points affect the cycle time, the time for each element of the cycle, and the pattern and time values for eye fixations under these various conditions.

The work cycle required the subject to reach with each hand to separate supplies of brass pegs, to grasp one peg with one hand, to move the pegs to adjacent holes, and to insert the pegs. An equal number of cycles were performed with dispensed pegs (orientation of pegs constant) and with jumbled pegs (pegs randomly oriented within a pan). For each of these variations in orientation, containers were placed at three locations; straight ahead (adjacent), 30 degrees to each side (moderately-spread), and 60 degrees to each side (fully-spread), with a constant distance of 15 inches from the insertion holes.

Ten male subjects, tested for handedness, eye dominance, and visual acuity, each performed a total of 5760 cycles during a six-weeks period. Practice with each of the variations of the cycle was concurrent so that transfer-of-learning effects were equally advantageous.

Cycle-time data were obtained for every run. Element-time data were recorded for each subject at three stages of learning. To chart the simultaneous activities of the two hands, a strip-chart recorder was employed, which was connected by electronic relays to the grasping containers and to the fixtures surrounding the insertion holes, in order to record the duration of each of the four elements of the cycle.

Eye-time data and eye-hand relationships were recorded by a movie camera mounted directly over the work table. Eye movements were shown by a small mirror placed on the work table.

Results of the experiment showed that increases in cycle time due to simultaneity (2-hand performance) were much greater (percentage-wise) for jumbled pegs than for dispensed pegs. From a different point of view, increases in cycle time due to random orientation (jumbled pegs) were much greater for 2-hand cycles than for 1-hand cycles. Spreading containers apart caused no significant difference in cycle time for dispensed pegs but caused significant, and progressive, increases in cycle time for jumbled pegs.

Element-time data showed that increased visual requirements in grasping (random orientation and spread locations) increased the time for the Grasp element more than any other element, but other elements were also affected. Random orientation caused significant (but varying) increases in time for all elements, both for 2-hand and 1-hand cycles. Simultaneity caused large increases in Insert time for both jumbled and dispensed pegs and also in Reach and Grasp time for jumbled pegs. Lateral (spread) locations of containers generally increased Grasp time, had no effect upon Insert time, and decreased Reach and Move times (especially with dispensed pegs).

Eye data produced some interesting results, especially in comparing sequence of fixations with handedness of the subject and in the effects of random orientation (jumbled pegs) upon eye-hand phase relationships. Further research is needed before recommendations can be made as to the optimum eye patterns and eye-hand relationships for each of these situations.

Limitations of the study were discussed and suggestions for further experimentation were indicated.

Comparisons were made of three

predetermined time systems against the figures we obtained in our research. The chart below shows the predicted increase in time, with the system involved, for the two-hand operations and the actual increase recorded in our experiments.

	Predicted			Actual
	MTM	System B	System C	
Dispensed Pegs	35%	3%	46%	21%
Jumbled Pegs	42%	8%	41%	31%

CONCLUSIONS

It is evident that conclusions drawn from the results of this experiment are limited by the following:

1. A select group of subjects were used, namely, upperclass male students in industrial engineering.
2. Only 10 subjects were observed. This is more than used for many industrial engineering experiments, but a small sample compared with the population.
3. All subjects had acceptable visual acuity (minimum of 20/30 Snellen rating), which perhaps should be required for similar industrial work but is not always controlled.
4. Only one size and shape of part (3/8-inch diameter by 2-inch brass cylinder) was used.
5. Only one class of fit (0.005 inch allowance) was used.
6. The last few pegs removed from the pans were not as difficult to select or grasp as the first ones (when the pan was filled).
7. Calculations involving element times, eye times, and eye-hand relationships used "typical" values, where extremely high and low values were deleted.
8. Subjects were asked to perform at "optimum pace" throughout the experiment, rather than at "normal" or "average" pace.
9. Subjects were aware of those runs which would be recorded for element times and eye data and may have performed at a somewhat different pace during these runs than during practice sessions where only run (cycle) time was recorded.

Within the limitations just described, the following conclusions are drawn from this experiment:

1. There is no single number which accurately expresses the effect of simultaneity (two-hand performance) upon cycle time for operations of various levels of complexity.
2. Increased complexity of grasp (including increased visual requirements) affects the cycle time for two-hand cycles much more than for corresponding one-hand cycles.
3. The effect of learning upon cycle time is about the same (expressed in percentage improvement) for two-hand cycles as for corresponding one-hand cycles.
4. Reaches to the side are preferable to straight-ahead reaches for one-hand cycles.
5. For simultaneous (two-hand) cycles, location of dispensers on the work table does not have a significant effect upon cycle time, provided the radial distance from dispenser to assembly point is kept constant and provided the angular displacement from the straight-ahead position is the same for each container. (Angular displacements greater than 60 degrees were not tested.)
6. For simultaneous cycles, adjacent location of pans (containing jumbled parts) is preferable (for minimum cycle time) to spread locations of pans because of the visual control required to grasp jumbled parts.
7. Random orientation of parts at the grasping point affected the time for the Grasp element considerably more than any other element but also caused significant increases in average time for each of the other elements.
8. Simultaneous performance of cycles affected the time for the Insert element, and the Reach and Grasp elements with jumbled pegs, more than the Move element and the Reach and Grasp elements with dispensed pegs. Simultaneity seems to have a greater effect upon performance time for complex elements (including increased visual requirements) than for simple elements.
9. Location of grasping points and orientation of pegs have combined effects upon element times for simultaneous cycles.

   (a) Spreading grasping points farther apart

increases the Grasp times to a greater extent for jumbled pegs than for dispensed pegs.

(b) The lateral location of grasping points (with spread containers) decreases the Reach time to a greater extent for dispensed pegs than for jumbled pegs.

(c) The lateral location of grasping points provides a small average decrease in Move time for dispensed pegs but a small average increase for jumbled pegs.

(d) Location of grasping points appears to have only random effects upon Insert time.

10. Over one-third of the subjects performed two-hand cycles with dispensers in spread locations without any eye fixations at one of the grasping points. Omission of this visual aid did not increase the cycle time over subjects who used visual aid for both grasping points.

11. Subjects who followed a consistent pattern of three eye fixations:

(a) Did not change the sequence of these fixations with practice.

(b) Did not change the sequence of these fixations for different location or orientation of pegs.

(c) Always terminated their fixation at the first grasping point during the early part of the Risch element.

(d) Almost always terminated their fixations at the second grasping point and at the insertion holes before the corresponding hand element was completed.

12. A majority (six out of nine) of the subjects with definite hand-preference gave their major visual assistance during Grasp to the preferred hand if they used a three-fixation pattern.

13. All (four) subjects in this experiment who used consistent two-fixation patterns for spread dispensers omitted their second fixation (watching Grasp at the second grasping point) and extended their first fixation (at the first grasping point) from a "glance" to a "watch."

14. Random orientation of pegs (jumbled) affected the duration of eye fixations:

(a) The "glance" and "insertion" fixations were longer for jumbled pegs than for dispensed pegs.

(b) The "grasping" fixation was longer for jumbled pegs than for dispensed pegs with three-fixation cycles.

15. Random orientation of pegs also affected the phase relationship between eye fixations and hand elements:

(a) The "insertion" fixation was terminated earlier (compared with the completion of both Insert elements) for jumbled pegs than for dispensed pegs.

(b) The "grasping" fixation was terminated earlier (compared with the completion of the Grasp element for the hand watched) for jumbled pegs than for dispensed pegs.

MISCELLANEOUS INFORMATION

Ten operators were used in this research project; each operator had ample opportunity to practice all of the conditions and variable layouts which were incorporated in this experiment. We found that there was considerable variance between operators. On the average, the poorest operator took 50% more time than did the best operator.

We did no pre-testing of the operators for dexterity since we were informed by our Industrial Psychologist that the best test of dexterity would be under the actual job conditions.

We used a 16 mm Eastman Special Camera with a wide-angle lens, having a constant speed drive which we set for 1,000 frames per minute.

APPLICATION

I

MTM STANDARD DATA FOR FOUNDRY OPERATIONS

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These MTM Applications are reprints from an MTM Seminar held in Chicago, Illinois, October, 1956.

It has been my experience to work on some unusual MTM installations in both light and heavy industry. These have included Crating, Packaging, Machine Shop Set-Up work, Inspection work and Foundry work; each of these installations has been successful.

In discussing foundry operations, I think we can all agree that actually we are discussing the principals in applying MTM to heavy operations regardless of where the operation is performed.

The main difference in performing a light or heavy operation is that when performing heavy operations, the body motions generally become very prominent. Therefore, since body motions are time consuming, we can expect heavy operations to be, on the average, longer in cycle times.

I would like to illustrate the difference in motions and time by moving two objects of exactly the same size and shape, but one weighing considerably more than the other.

The operation is to move the box from the table to the chair directly in back of me. The operation ends after I have turned back to the table again. I will stand approximately 12" from the table and the distance from the edge of the table to the edge of the chair is 30".

The method required to move the light box is as follows:

L.H.	TMU	R.H.
R14B	14.4	R14B
G1A	2.0	G1A
	37.2	TBC2
	29.0	B
RL1	2.0	RL1
	31.9	AB
	37.2	TBC2
TOTAL TMU	153.7	
MINUTES	.0922	
SECONDS	5.5332	

The same operation with the heavier box is considerably different.

L.H.	TMU	R.H.
	30.0	W2P
~~R6B~~ ~~G1A~~		~~R6B~~ ~~G1A~~
AP1	16.2	AP1
M2B50/2	15.0	M2B50/2
	37.2	)TBC2
	37.2	)TBC2
	29.0	B
RL1	2.0	RL1
	31.9	AB
	37.2	TBC2
TOTAL TMU	235.7	
MINUTES	.1414	
SECONDS	8.484	

As I go through the two operations, you will have a clear comparison of the two. Those of you who know MTM will readily recognize and understand the motions. However, those who are not experienced in MTM will still be able to follow the operation and understand fully what happens to a method when we add weight to an operation.

To perform the operation for the light object, which weighs 4 pounds, we begin by reaching both hands 14" to the handles on each side of the box. This is done by an R14B. We use a case B reach even though the handles are fixed on each side of the box since the box will vary in location from cycle to cycle. Next, the handles are grasped by a simple G1A. To get the body into position so that the box can be placed on the chair, the body pivoted on the ball of one foot 180^{o} and the lagging leg is brought into position by what we call a TBC2. A little later you will notice that to turn the body 180^{o} while carrying a heavy object, a different method will be used. The box is then set on the chair by a bend body, B, and a simple release, RL1. To complete the operation, the operator makes an arise bend, AB, and turns body to the table by

another TBC2 pivoting on the ball of the foot. If the operator was going to reach for another object, the lagging leg, or the reach, would be limited out depending upon which required the most time.

Now, let's consider the same size and shape box but weighing 50 pounds. To pick up the heavy box, the operator must first walk two paces, W2P, to the table to avoid straining his back while lifting. Reaching to the box handles, R6B, are limited out by the first pace and the grasping of the handles, G1A, are limited out by the second pace. Therefore, we allow time for walking two paces only. In order to start the box in motion to lift it off the table, an applied pressure, AP1, is necessary. Next, the operator moves the box up approximately 2", M2B50/2, as it is difficult to slide a heavy object during a turn body and also we could scratch the table. Next, we turn to the chair and do this, two distinct 90° turns are made, TBC2, and in each case, the lagging leg must be brought into position before the next motion can be made. The remainder of the operation requires the same motions as the lighter box. That is, bend body, B, to move the box to the chair and release, RL1, the box after it has made contact on the chair seat. Arise bend, AB, and turn, TBC2, to the chair completes the operation.

By comparing the total times of the two methods, we readily see that the method in which the average operator uses to handle the heavy box requires approximately 50% more time than the lighter box. This is due to the extra body motions which are required to perform the heavy box method. A stop watch engineer might try to assign these operations the same time or level the heavier method to slightly more time than the lighter box by what they call the comparison method of time study.

Exhibit I is a check shset which is currently in use at a foundry in the St. Louis area. This form is used to extablish consistent time standards for small machine molding. It is an excellent method of setting consistent time standards for a given method where time formulas or charts cannot be used. Naturally, if charts can be used, more standards per hour, with less chances for errors can be set. For molding, we found that check sheets were necessary. With this form, we were able to set approximately twenty standards per day (8 hours) with an average operation cycle time of approximately four minutes.

To use this check sheet, you merely check the elemental times for the elements necessary for the operation and extend them to the allowed time column. By totaling the allowed elemental times you get the total base minutes. The remainder of the study is calculated as usual, delay allowances depending upon the individual plant's practice.

I would like to make a few comments on the Unions, C.I.O. Steelworkers, acceptance of MTM in the foundry in which I was employed. The working agreement, the contract, permitted the union to appoint an individual from their group, a person acceptable to management, to work in the Industrial Engineering Department. Fortunately, we chose an individual who was intelligent and fair minded. This contributed to good cooperation between the union and management and played an important part to a successful wage incentive installation. Because I could trust the union man, I would permit him to recheck most of the jobs in which we had received a dispute. His dealings were fair and in practically all cases he would rule in favor of the existing standards. Only when he found method changes, was a standard changed. Many of the factory employees, themselves, became fascinated with the system we used to install standards since we seldom had need for a stop watch and at their request we conducted a course, permitting any employee in the factory who registered, to take a course in MTM. About fifteen (15) employees took the course which was conducted two nights a week and on the employees' own time. Each session lasted 1-1/2 hours and the total course was about 80 hours. This training helped to sell the MTM system to the shop.

A person not experienced in establishing standard times in heavy industry may make the mistake of giving an excessive fatigue allowance where it is not needed. Fatigue is one subject which we could discuss and probably not come to a complete agreement. We all have our opinions as to whether it should be a factor in the Delay Allowances or not. However, in heavy industry, you can easily be swayed into giving an operator excessive fatigue allowances. Usually, heavy weights are not handled as often as you might suspect, 15 to 20 percent of the total cycle time is often a close estimate.

Since heavy industrial operations are usually long in cycle time, it is not uncommon to find that the weights are not actually handled over 45 to 60 minutes out of an 8-hour day. The remainder of the day is utilized basically the same as in lighter industry. Look at your molding check sheet, you will notice that we have times for placing nails and chills in the mold (actually sticking nails and rods in sand), positioning small cores, stamping the mold and etc., which are light operations. Only when the Cope and Drag are lifted is the weight actually handled by the operator.

The other day in our Punch Press Department, at Fred Medart Manufacturing Company, I noticed a Brake Operator forming a 90° edge on a part called a Wire Basket Shelf. There parts are made from 22 gauge sheet steel 19" x 44-1/2" and weigh about 6.9 pounds each. The operator would form each part and set it aside on a shelf built on the front of the press. When he had accumulated ten parts, he would lay aside the parts on a skid which was on the floor just to the left of the machine. This means that after every 10 parts or 1.20 minutes, he would handle about 69 pounds. The operation was being performed by one of the smallest men we have in our shop, about 5 feet 5 inches in height, but stockily built. Naturally, our standards are not established on handling this amount of weight, as we have set a limit to how much weight we can expect an average operator to handle. Instead of stopping the operator, I permitted him to continue handling this weight to illustrate to some of the engineers in my department what ill effects or loss in production this operator might experience by handling this weight. Several times during the day and toward the end of the shift, we checked the operator to try and determine if any changes were taking place. Our findings during each check were that the operator was producing approximately the same number of pieces, exceeding the standard and at quitting time left the plant in a cheerful mood, apparently suffering no ill effects from handling the weight. This coincides with my experience in other plants. Let me make clear, however, I do not advocate handling excessive weights as a person may be injured seriously. I am merely trying to caution you not to be confused into giving excessive fatigue allowances for handling heavy objects. Naturally, there are other factors which must be considered in determining fatigue. How much an operation time is effected, if any, by these factors which are said to create fatigue has never been accurately measured, as far as I know, and because the unknown creates arguments, I will not discuss them in this talk.

In conclusion, we can agree that basically there are no differences as to the principals of applying MTM to either light or heavy industrial operations. In each case we are concerned with the motions necessary to perform an operation for an established method. In handling heavy objects we can expect to encounter more body motions. We must be on our guard in all types of operations not to include excessive allowances for such items as fatigue or allowances for conditions the operator is being compensated for in his base rate whether determined by Job Evaluation or not.

EXHIBIT I
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Rev. 9-15-53

STERLING STEEL CASTING CO.

Std. Time Check Sheet Small Molds Milwaukee Jolt Squeezer

Oper. L.F. %

Cycle Time			AV.	L.T.

T.S. NO. _____ DATE _____
CUSTOMER _____
PATTERN NO. _____ FLASK SIZE ___ x ___ x ___ C/D
CASTINGS PER MOLD _____ SPRUES _____ HEADS _____
CORES ___ C/D NAILS ___ C/D CHILLS ___ C/D ARBORS ___
CHAPLETS ___ ___ POPOFFS ___ VENTS ___ OTHERS
OBSERVER _____ APPROVED _____

Code	Elemental Description		Element Time	Occ. Mold	All'd. Time
	DRAG TIMES ONLY				
01	Flask size	12 x 12; 12 x 14	.6133	1	
		12 x 16, 12 x 18, 14 x 14, 14 x 16	.6220	1	
		12 x 20, 14 x 20, 16 x 16	.6285	1	
		12 x 32, 16 x 20	.6402	1	
		14 x 24	.5645	1	
		12 x 36	.6302	1	
02	Vol. of sand (to 14 x 24 flask)	450 to 750 cu. ins.	.4331	1	
		751 to 1050 cu. ins.	.4593	1	
		1051 to 1350 cu. ins.	.4835	1	
		1351 to 1650 cu. ins.	.5177	1	
		1651 to 1950 cu. ins.	.5516	1	
		1951 to 2250 cu. ins.	.5858	1	
		2251 to 2550 cu. ins.	.6130	1	
		2551 to 2850 cu. ins.	.6422	1	
		2851 to 3150 cu. ins.	.6734	1	
03	Vol. of sand (14 x 24 & incl. 12 x 36 flask)	1051 to 1350 cu. ins.	.5009	1	
		1651 to 1950 cu. ins.	.5690	1	
		1951 to 2250 cu. ins.	.6032	1	
		2551 to 2850 cu. ins.	.6596	1	
		2851 to 3150 cu. ins.	.6908	1	
		3451 to 3750 cu. ins.	.7442	1	
		3751 to 4050 cu. ins.	.7784	1	
164-M	Complete filling 7" thru 9" depth flask (after jolting)		.0815	1	
75-M	Position one or more nails or chills in drag				
	(1) .0850 (2) .1329 (3) .1741 (4) .2518 (5) .2930 (6) .3342 (7) .3754 (8) .4166				
	(9) .4578 (10) .4990 (11) .5402 (12) .5814 (13) .6226 (14) .6638 (15) .7050 (16) .7462				
25-M	Position one or more cores in drag				
	(1) .0827 (2) .1390 (3) .1867 (4) .2444 (5) .2821 (6) .3299				
	(7) .3776 (8) .4253 (9) .4730 (10) .5207 (11) .5684 (12) .6161				
57-M	Position mold arbors			1	
	(2) .0959 (3) .1220 (4) .1482 (5) .1744 (6) .2005				
56-M	Stamp drag			1	
	(1) .0837 (2) .1095 (3) .1353 (4) .1611 (5) .1569				
	(6) .2127 (7) .2385 (8) .2643 (9) .2901 (10) .3159				
82-M	Move drag to conveyor (14 x 24 & 12 x 36 only)	Two men (includes waiting for helper)	.4522	1	
17-M		One man	.0757	1	
123-M	Extra jolling time (depth of drag)			1	
	(6") .0350 (7") .0840 (8") .1400 (9") .1890				
	COPE TIMES ONLY				
04	Flask size	12 x 12, 12 x 14	1.0686	1	
		12 x 16, 12 x 18, 14 x 14, 14 x 16	1.1195	1	
		12 x 20, 14 x 20, 16 x 16	1.1624	1	
		12 x 32, 16 x 20	1.2382	1	
		14 x 24	1.0858	1	
		12 x 36	1.1884	1	
05	Vol. of sand	450 to 750 cu. ins.	.5470	1	
		751 to 1050 cu. ins.	.5692	1	
		1051 to 1350 cu. ins.	.5924	1	
		1351 to 1650 cu. ins.	.6176	1	
		1651 to 1950 cu. ins.	.7199	1	
		1951 to 2250 cu. ins.	.7541	1	
		2251 to 2550 cu. ins.	.7965	1	
		2551 to 2850 cu. ins.	.7525	1	
		2851 to 3150 cu. ins.	.8667	1	

EXHIBIT I
Page 2 of 2

Code	Elemental Description		Element Time	Occ. Time	All'd Time
06	Vol. of sand (14 x 24 to & incl. 12 x 36 flask)	1051 to 1350 cu. ins.	.4070	1	
		1651 to 1950 cu. ins.	.4354	1	
		1951 to 2250 cu. ins.	.4496	1	
		2551 to 2850 cu. ins.	.4780	1	
		2851 to 3150 cu. ins.	.4922	1	
		3451 to 3750 cu. ins.	.5206	1	
		3751 to 4050 cu. ins.	.5348	1	
74-M	Position one or more nails or chills in cope				
	(1) .0727 (2) .1261 (3) .1673 (4) .2450 (5) .2862 (6) .3274 (7) .3686 (8) .4098				
	(9) .4510 (10) .4922 (11) .5334 (12) .5746 (13) .6158 (14) .6570 (15) .6982 (16) .7394				
30-M	Position one or more cores in cope				
31-M	(1) .0730 (2) .1322 (3) .1798 (4) .2246 (5) .2752 (6) .3229				
	(7) .3706 (8) .4183 (9) .4660 (10) .5137 (11) .5614 (12) .6091				
11-M	Position one or more sprues & risers (symmetrical)			1	
	(1) .0457 (2) .0608 (3) .1065 (4) .1216 (5) .1673 (6) .1824				
165-M	Position one or more sprues & risers (semi & non symmetrical)			1	
	(1) .0604 (2) .1208 (3) .1812 (4) .2406 (5) .3010 (6) .3614				
47-M	Remove one or more sprues & risers				
	(1) .0695 (2) .1018 (3) .1713 (4) .2036 (5) .2731 (6) .3054				
101-M	Remove one or more sprues & risers (so short that finger can't grip firmly)			1	
	(1) .1243 (2) .2194 (3) .3145 (4) .4096 (5) .5047 (6) .5998				
44-M	Ream one or more sprues & risers (outside)			1	
	(1) .0800 (2) .1291 (3) .1782 (4) .2273 (5) .2764 (6) .3255				
45-M	Ream one or more sprues & risers (inside)			1	
	(1) .1103 (2) .1550 (3) .1997 (4) .2444 (5) .2891 (6) .3338				
3-M	Squeeze mold (no. of sprues & risers)			1	
	(1) .2114 (2) .2238 (3) .2488 (4) .2888 (5) .3588 (6) .4488				
12-M	Pack facing sand around one or more sprues. (sand gotten from bin on floor)			1	
	(1) .1109 (2) .2218 (3) .3327				
145-M	Pack fill sand around sprues & risers (3 or more)			1	
	(3) .1386 (4) .1848 (5) .2310 (6) .2772				
55-M	Make one or more popoffs			1	
	(1) .1006 (2) .1710 (3) .2396 (4) .3091				
35-M	Make one or more vents			1	
	(1) .1030 (2) .1251 (3) .1472 (4) .1693 (5) .1914				
	(6) .2135 (7) .2356 (8) .2577 (9) .2798 (10) .3018				
56-M	Stamp cope			1	
	(1) .0837 (2) .1095 (3) .1353 (4) .1611 (5) .1569				
	(6) .2127 (7) .2385 (8) .2643 (9) .2901 (10) .3159				
	Move cope to conveyor (14 x 24 & 12 x 36 only)				
82-M		Two men (includes waiting on helper)	.1618	1	
17-M		One man	.1524	1	
	COPE AND DRAG TIMES				
4-M	Extra shovel of facing sand & extra Riddling (deep ptn.)				
90-M			.3403	1	
145-M	Arrange and pack facing on ptn. (each location .0231)				
41-M	Shove molds down conveyor (all except 12 x 32, 12 x 36, 14 x 24)		.0379		
		12 x 32, 12 x 36, 14 x 24	.0758		
42-M	Place 4" x 22" boards on conveyor. (all except 12 x 32, 12 x 36, 14 x 24)		.0394		
		12 x 32, 12 x 36, 14 x 24	.0787		
18-M	*Place pallet on conveyor (all except 12 x 32, 14 x 24, 12 x 36)		.0307		
		12 x 32, 14 x 24	.0613		
	*NOTE: For 12 x 36 the pallet serves as both plate and pallet.	12 x 12, 12 x 14	.2476		
77-M	Make special heat (dust top of mold).		.0443		
79-M	Make basin on top of mold.		.0662		
80-M	Helpers time (12 x 36 only)		.5818		
81-M					
82-M					

ELEMENT NAME	1	2	3	4	AV.T.	L.F.

	TOTAL MINS.	
PLUS	% ALLOWANCES	
DIVIDE BY	CASTINGS PER MOLD	
DIVIDE BY 60	HOURS EACH	
DIVIDE INTO 1	PCS. 1 HOUR	

APPLICATION II

BETTER PLANT LAYOUT THROUGH MTM

Earl Kiehn
The Maytag Company
Newton, Iowa

The Maytag Company recently has completed two new assembly lines to produce automatic clothes dryers and a new model automatic clothes washer. The new automatic dryer assembly line is the one that I would like to talk to you about today.

To remain competitive in the household appliance business today, a manufacturer must be equipped to produce in large volume and must take full advantage of the best equipment to produce quality products at a low cost. Our Vice President of Manufacturing suggested that we utilize the 70 hours of MTM training given our foremen, as well as the 105 hours given to the production engineers, to come up with plans for the new facilities. In April, 1955, he called a meeting of management personnel including the Plant Manager, the Managers of Inspection, Production Control, Production Engineering, Industrial Engineering, Purchasing and the Dryer Department Superintendent to initiate plans for manufacture. He informed the group that the assembly line must be capable of producing six different models of dryers, each with a choice of four colors, and at a production rate of 1,000 dryers per eight hours. The space available in the plant measured 100' x 700' long. He stated that:

> "We want the best layout for the full utilization of space and manpower, and we want you to contribute every original and unusual idea which you can come up with to achieve the best and lowest cost assembly! We don't want a second-hand layout from some other company, but a layout to best suit our product design. Your training and experience in Methods-Time-Measurement should guarantee an excellent job.
>
> "After we at Maytag have exhausted all of our ideas, we will then consult outside conveyor companies for their proposals. We will incorporate their ideas with ours, so as to come up with the best layout using the newest equipment available today. An MTM analysis should be made of all operations including the assembly, inspection and crating."

The Dryer Committee was then formed with the Superintendent of the Dryer Assembly as the chairman. The number of men assigned from the different departments varied from time to time, depending upon the project requirements.

Let us now examine the possibility of using the highly developed technique of Methods-Time-Measurement to lay out facilities to achieve the lowest cost production. We had already been producing several models of dryers at a maximum rate of 250 per eight-hour shift on an assembly line in a crowded area where good layout was impossible. This resulted in considerable manual handling of parts and machines, caused rework operations, and resulted in high costs. Maytag now wanted to produce these dryers at the rate of 1,000 dryers per eight-hour shift. Obviously, therefore, the facilities and layout were a very important consideration.

My presentation today is broken down under four divisions:

I. Analysis of the product and facilities required.

II. Work with outside conveyor companies.

III. Specific applications and cost reductions resulting from MTM analyses.

IV. The over-all benefits obtained from using MTM to plan a layout.

I. ANALYSIS OF PRODUCT AND REQUIRED FACILITIES

Since the elemental times for the old layout were of little value, and the request of our Vice President of Manufacturing was for the establishment of the most modern and efficient method of assembly, we decided the project would require complete new MTM analysis. We, therefore, assigned two of our engineers with the best MTM experience to do the detailed analysis of the necessary operations for assembly. A third engineer was assigned to represent Industrial Engineering activities with other departments. He would consult with the Final Inspection Department to obtain inspection requirements; with the Design Department concerning product changes

and make recommendations resulting from MTM analyses.

An analysis of the products involved revealed:

1. There were approximately 488 parts in the model which would require assembly.

2. On six models, approximately 750 different assembly parts needed consideration.

3. Breakdown of six models was:

   2 Models - Gas - Standard & Deluxe (blower type)

   2 Models - Electric - Standard & Deluxe (blower type)

   2 Models - Electric - Water Condenser Type

And each of these came in four different colors!

Before the project was complete, five newly designed models had to be considered for assembly over the same line.

4. The parts varied in size, shape, and material. Some special parts were cabinet top, cabinet sides and front, control panel, base frame, electric motor, timer, wiring harness, drum, etc.

In order to make the layout, the engineers first had to understand the function of the parts, and consider various possible methods of assembly. A team of engineers, line foremen, and inspectors tore down and reassembled the dryer many times and analyzed the process with MTM. They attempted to examine various possible methods of assembly, and then to design the best layout which could be economically justified.

At the rate of 1,000 dryers per eight-hour shift, the work cycle of each operator would be approximately 0.50 minutes. Based on this time, MTM was used to determine the exact operations which would be done at each station.

A rough sketch of each work station layout was made to determine the length of "reaches and moves, body motions," etc., as well as the over-all space required by the work station. This was to be used later in laying out the assembly line. The principal feature of the sketches were:

1. These sketches were drawn approximately to scale, showing the position of the parts on the assembly conveyor. Our research indicated the best height of the conveyor or distance from the floor should be 30".

2. Required materials were coded by letters, listed, and shown in their proper location.

3. Recommended equipment was coded by numbers and also shown in proper locations. This included special equipment, such as gages, as well as standard equipment like bin boxes, power nut runners, etc.

4. Different models of dryers which could be assembled using the layout were listed in the lower right-hand corner.

5. The over-all station space which would be required in preparing the assembly line layout was shown.

After the MTM engineer had completed the sketch, it, together with the MTM analysis, which included equipment recommendations, was reviewed by the line foremen and the Dryer Committee to insure acceptance of the station layout, equipment, and operator work load.

The space required for the entire dryer line was then determined as follows:

1. The individual work station layouts were consolidated to indicate the over-all space requirements for the sub-assembly lines.

2. The layout of the sub-assembly lines were issued to determine where the overhead delivery conveyors must drop down to deliver the major parts to the line.

3. All the work stations for the sub-assembly and main assembly lines were consolidated on a two-dimensional layout to make maximum use of the space available.

4. All the MTM elements were coded and filed for future references to establish estimates and labor standards.

A typical example of the improvements that resulted from the new layout is the operation of assembly of the drum. The old method was as follows:

1. Four different fixtures were used to complete the necessary assembly and gage of the height and concentricity of the drum.

2. The drum was handled five times before placing on belt delivery line to the main assembly line. Just think of all of these possible chances of chipping the porcelain in handling the drum!

3. Material to be assembled was inconveniently located and the area was cluttered.

Industrial Engineering recognized the excessive amount of handling that was occurring in the old layout of the drum assembly. The MTM analysis indicated the possibility of combining four gaging operations on one fixture. This idea, and the possible cost reduction, was discussed with the tool engineer, and the new gaging fixture was designed and planned in the layout, with the following features:

1. One fixture incorporates all gaging, and eliminates the extra handling of the bulky parts.

2. The porcelain chippage was substantially reduced as a result of the reduced handling.

3. Material to be assembled to the drum was located more conveniently and the area is uncluttered.

4. The reduction in labor for this drum assembly amounted to 18% over the old method, or a labor savings of $7,500 per year, excluding the savings in rework.

5. Cost of installation was $10,250 so that the installation paid for itself in 1-1/2 years.

II. OUR WORK WITH OUTSIDE CONVEYOR COMPANIES

1. With the completion of MTM analyses, and a rough sketch of the main assembly and subassembly lines showing space required, height of the lines at various points, etc., outside conveyor companies were consulted and asked to submit proposals on the project. These companies were offered copies of the MTM analyses with station sketches. For easy identification of these conveyor companies, let us refer to them as "X" and "Y" Companies.

"X" Company immediately asked for the complete information, where "Y" Company stated that they could develop their own times and sequence of operations. In fact, "Y" Company offered to furnish us copies of their times of assembly to compare with our MTM analysis times! As it turned out later, they submitted their first proposal with operations completely out of sequence, operations not being performed on the correct side of assembly line, and areas of assembly out of proportion to actual space required. After calling these items to their attention, "Y" Company immediately asked for copies of MTM analyses, work station sketches, and the two dimensional layout.

2. Comments made by conveyor companies in using MTM for layout. While the conveyor companies were preparing their proposals, they expressed certain thoughts concerning the use of MTM for better plant layout:

   (a) The MTM analysis and station layouts were the most complete set of information that they had received on any of their installations.

   (b) The companies stated they felt that they were in a better competitive position because they had the same information.

   (c) They also stated that we, ourselves, through the use of MTM, were better able to compare and evaluate the proposals submitted by the various companies. As an example, some of the companies submitted as many as three different types of conveyors for feeder lines. Through analysis with MTM, we were able to reach agreement on which conveyor was best suited.

3. Conveyor companies submit their original proposals.

   (a) "X" Company submitted individual carrier overhead monorail layout.

   (b) "Y" Company submitted a layout proposing dollies on which the dryer would be assembled and pulled along by a power chain recessed in the floor.

   (c) Maytag Company had made a layout using power belt and slat-type conveyor.

Now that we had three types of conveyor proposals, we could evaluate with MTM which would best fit our assembly requirements and result in lowest cost assembly.

4. Comparisons of equipment.

   (a) The overhead monorail system was found to be the best suited due to its flexibility and automaticity. Carrier used because:

      (1) Operator can move around dryer—no hopping over conveyor.

      (2) Operator can work on bottom of dryer easier.

      (3) Dryer is kept on its carrier throughout the entire system. There is no manual handling of the machine.

5. Approvals of the assembly lines. After a number of proposals were received and evaluations made of each layout with MTM, one proposal was selected and contracts awarded to one company for installation of the new assembly line. The assembly line cost approximately one million dollars, including overhead carriers.

III. SPECIFIC APPLICATIONS RESULTING FROM MTM ANALYSIS

Now that you have seen how the project developed, I would like to give a few specific examples of cost reductions:

1. Cost reduction in product design. Wire harness (601C) was changed from a two-piece harness to a one-piece harness. This resulted in a savings of electric connectors, electrical wiring, and labor of $.08 per machine, or approximately $18,000/year.

2. Fixture design.

   (a) Control panel assembly fixture. An improved fixture which could be used to assemble two types of control panels resulted in a labor saving of $10,000 per year, cost $7,500, and paid for itself in less than a year. The conveyor company had recommended two separate fixtures. The MTM analysis proved that it could be done with one fixture.

   (b) Cabinet line. New fixtures were designed which positively located the cabinet, reduced handling, and resulted in a savings of $3,800, cost $6,500, and paid for itself in less than two years.

3. Work simplification.

   (a) Assembly of pump and blower. The use of good layout and bins resulted in savings of $5,200, at cost of $10,400. Again, the MTM analysis proved that the same fixture could be used for both the pump and the blower. The conveyor companies had recommended separate fixtures and the foremen had agreed!

4. Inspection and testing. Due to the increased production required from the new line, and the fact that the machines were to be conveyed automatically through the inspection and testing operations compared to the former manual handling, the Inspection Department requested our assistance in determining.

   (a) Their manpower requirements.

   (b) The best sequence of inspection operations and the work place layout for each inspection operation.

Our analyses resulted in suggestions, such as the following:

   (a) Use of a multiple electrical connector for testing machines instead of individual wire connections.

   (b) With out new monorail power individual carrier assembly, machines go continuously through tests and are kept off the floor, thus eliminating possibility of scratching due to manual handling. Also, there are no banks on floor, frees space, better housekeeping, greater operator safety, etc.

The functional test loop, which is an integrated part of the monorail conveyor system and which provides full cycle testing of the dryer, provides movable connections coordinated with the conveyor system for electricity, natural gas, LP gas, and water. If adjustments are needed after any of the inspection operations, the inspector merely raises a flag attached to the carrier, which automatically sends the unit into the necessary rework area. When a machine is taken off the main line, another leaves the work area, automatically filling the gap.

Upon completion of the final inspection operation, the machine is mechanically transferred from the monorail carrier to an automatic packaging machine.

Once the dryer enters the crating machine, the monorail carrier is returned by overhead conveyor to the front of the main assembly line, where it begins a new cycle.

5. Delivery of parts to the assembly line presented a problem due to their size, and the fact that the departments where they were processed were located at a distance from our assembly line.

Conveyor hangers were designed to meet the specific requirements of the different models, as well as for convenience in loading the parts in the Paint and Porcelain Departments, and removing them in the assembly area.

It was decided to deliver the painted and porcelain parts to the assembly area by overhead conveyor. The Porcelain and Paint Departments had to operate two eight-hour shifts per day to supply enough parts for one eight-hour shift on the assembly line, so the conveyor was designed to provide for storage of parts during the shift when the assembly line was not operating.

These delivery conveyors have a total length of just over two miles, up on the roof, as well as 15 lengths on ceiling! They drop down seven times to deliver parts to the assembly line. These conveyors carry at least one day's storage of parts so that production in the Assembly Department will not be curtailed in the event of short interruptions in the Finishing Departments.

IV. BENEFITS FROM MTM IN PLANNING THIS SYSTEM

With a little over two months having elapsed since the assembly system was installed, we have had an opportunity to factually evaluate the advantages of the MTM procedure of analysis. Here are some of the main benefits which we believe attained:

1. MTM analyses led to many changes in designs of both parts for the dryer and fixtures to assemble them. This resulted in reduced cost of materials and simplifying the assembly work.

The analyses also enabled us to specify the most economical types and quantity of equipment, such as hand tools, power nut runners, stock bins, tables, etc.

2. Outside conveyor companies appreciated the value of MTM analyses in making up their proposals. Their bids were complete, with very few additions or changes required later.

We were confident that we were getting the lowest price because the specifications were exact and the bidders did not have to include a cost factor for unknowns.

3. Production supervisors worked closely with the engineers and having reviewed the MTM analyses and work station sketches, were completely familiar with the details before actual installation of the equipment was started.

4. With MTM we provided production supervisors with complete descriptions of the work each operator would do. This was of great assistance in training the operators.

Also through the use of MTM, labor standards for each operation were available before starting production, resulting in rapid application of wage incentives.

5. Perhaps most important of all, the MTM analyses uncovered many problems which would have otherwise confronted us and caused confusion when production started. The analyses forced us to make decisions, and take action in the planning stage, when changes could be made without adding to the cost of the installation. Actually, there were few changes necessary after the equipment was installed. This was a far different situation than when previous installations had been made without the use of MTM.

Finally:

We are convinced that MTM has played an important part in developing what we believe is the most modern and efficient assembly line of its type in the world!

DISCUSSION PERIOD ANSWERS

Maytag does not have over-all cost figures and saving figures that were attained by this layout program; furthermore, we think that the labor saving was not the greatest advantage of the program. We believe that the greatest advantages of this program were the better quality that was attained through better handling of materials, increased output, and, most important of all, the reduction of chippage on our units.

The complete time that elapsed between the beginning of this program and the complete installation was approximately 15 months.

Operator reaction to such a program was generally good. We had no serious problems, although we did have some minor grievances. We found also that we were better equipped to balance the individual work stations on the line.

Fifty-two people were involved in this layout, which was designed to produce 1,000 units per day. We are currently at a production level of 600 units per day, and we figure that the total reduction in personnel when we reach 1,000 per day will be approximately 19%.

At the present level of 600 units per day, we have found that the MTM analysis has helped us considerably in rebalancing the work stations for the lower production figures under which we are now operating.

Three full-time Industrial Engineers were involved in the layout of this particular line. In addition, we had one Methods Engineer and the Tool Engineering and Production Engineering Departments were used whenever necessary.

We feel the greatest advantage that was derived from our 70-hour instruction program in MTM to supervisors was the ability to have them become acquainted with the MTM method and the methods employed on the layout through the use of MTM, as well as the advantage of the foreman being able to help himself work up better methods to improve the over-all efficiency. In addition, we feel that we had better cooperation between the supervisors and the Industrial Engineering Department through the MTM program.

We used the foremen also to train the operators in the proper method following the MTM analysis of the job.

MTM AT COLLEGES AND UNIVERSITIES

Recently, the MTM Association completed a survey of colleges and universities inquiring into the extent to which MTM has become a part of the Industrial Engineering or Management curriculum. The results show an interesting growth and acceptance of MTM.

Of the questionnaires sent out, 22 replies were received. As there are only slightly more than sixty schools offering curricula in Industrial, Management or Administrative Engineering, this represents a response only a little under forty percent of the possible responses, and is large enough to lend some weight to the information contained therein.

Of the responding schools, 100 percent indicated that MTM was in some way part of their curricula. A similar survey was made in 1954. The breakdown showing to what extent MTM has been included in the program is as follows:

1954	
As a separate course of study	17.2 percent
As part of a more general course	79.3 "
As an informal lecture or discussion	17.2 "
As a clinic or conference	17.2 "
1957	
As a separate course of study	27.6 "
As part of a more general course	90.5 "
As an informal lecture or discussion	9.5 "
As a clinic or conference	9.5 "

The most widespread use of MTM was as part of a more general course of study. An interesting point is the fact that MTM was usually discussed in these courses along with the general subject of Standard Data and usually one or two other predetermined motion time systems. The significant point is that no other system has been as consistently included as MTM. Other systems were discussed, spread over 23 different schools, one or two to each school, while MTM was discussed in all 21. In addition there has been an increase in separate MTM courses from 17.2% to 27.6% in schools reporting. No school indicated similar courses in any other system.

Following is a breakdown showing the average number of hours spent on MTM in these courses and also the range of hours:

1954	Average	Range
As a separate course	47 hrs.	36 to 60 hrs.
As part of a general course	20.1 hrs.	5 to 39 hrs.
As an informal lecture or discussion	1.2 hrs.	1 to 2 hrs.
As a clinic or conference	29.8 hrs.	3 to 66 hrs.
1957	**Average**	**Range**
As a separate course	58 hrs.	34 to 120 hrs.
As part of a general course	12 hrs.	1/2 to 36 hrs.
As an informal lecture or discussion	2 hrs.	1 to 3 hrs.
As a clinic or conference	30 hrs.	

It is important to remember that the number of hours listed for regular courses refers to classroom hours and does not usually include homework or laboratory work. This breakdown indicates that the student is receiving a considerable amount of orientation in MTM principles, more than would be expected on a purely appreciation level. In fact, the consensus of schools replying was that the student is achieving a competence great enough to make some immediate use of his knowledge of MTM, at least in the various applications to methods work. None of the schools, however, claimed that their students were completely trained in MTM, but, in varying degrees were given a thorough academic introduction to it.

What then are the numbers of people being reached by this program in the colleges and universities? Following is a listing in terms of the average number of students in each category, and comparison with the 1954 figures:

1954	Average	Range
As a separate course	15	8 to 20
As part of a general course	45.2	10 to 120
As an informal lecture or discussion	86	19 to 200
As a clinic or conference	74	10 to 183
1957	**Average**	**Range**
As a separate course	23	10 to 50
As part of a general course	60.6	3 to 300
As an informal lecture or discussion	122	70 to 200
As a clinic or conference	4	

The total of all persons participating in these activities was 1,659 persons, a considerable number considering the relatively short time that MTM has been in existence. In addition, considering the fact that less than half of the possible schools have responded in this survey, and that all the colleges and universities having an Industrial Engineering or related curriculum have only a reported some 6,000 students, both undergraduate and graduate, the figure of 1,659 persons reached during the period covered by the survey is quite large. The figures of the survey refer to a period of roughly one year and to less than half the colleges and universities. Students remain so for four to five years. It would not be too ridiculous to hypothecate that a vast majority, if not nearly all, Industrial Engineering students are receiving some orientation and possible training in MTM on a small scale prior to their graduation. The comparisons shown and described point to a continuing growth and use of Methods Time Measurement.

MTM NEWS

CHAPTER NEWS

CINCINNATI CHAPTER

Professor Harold Puff addressed the October 29th meeting on the subject "Teaching MTM," and "Some Applications." Professor Puff is Acting Chairman of the Department of Industrial Management, School of Business Administration, Miami University.

In October, the Cincinnati Chapter's representatives conducted the Introductory Program at the Fifth Annual International MTM Conference at the Hotel Statler, New York City.

Robert E. Atkinson, Leonard Nipper, Floyd B. Sallee, William Taylor and Robert Westbrook gave an interesting program in MTM fundamentals.

The November 26th meeting's subject, "National Association and Chapter Relationships," was presented by the MTM National Secretary, Richard F. Stoll. The talk covered: 1) An explanation of the cooperative relationship between chapters and the national organization, 2) An outline of the development of an International Directorate, and 3) showing of a film depicting the use of MTM in planting, cultivation, and harvest of Florida truck-garden crops.

SOUTHERN CALIFORNIA CHAPTER

As featured speaker at the October meeting, Wade B. Carter, Plant Industrial Engineer, Menasha Container Corporation, spoke on "MTM in a Box Factory."

A special report on the International Conference was an additional program highlight.

Vern Pope, Director of Industrial Relations, Grayson Controls Division, Robertshaw-Fulton Company, discussed the relationships generated in an industrial wage incentive environment pursuant to such personnel problems as absenteeism, turnover, probationary employees, accident rates, selection and placement of employees.

ST. LOUIS CHAPTER

David L. Raphael, Research Associate, University of Michigan, spoke on the subject: "Latest Developments of MTM Research," at the November meeting of the Chapter.

DINNER MEETING-BOARD OF DIRECTORS, OCTOBER 3, 1956,
Hotel Statler, N.Y.C.

Personnel attending

Front Row, from left to right: D. G. Stohlman, Serge A. Birn Company; Mrs. McCullough, Jack McCullough, Victor Gasket Manufacturing Company; Mrs. T. W. Cameron, MTM Association; A. H. Walter, A. T. Kearney Company; President John A. Willard, Bigelow, Kent, Willard & Company; Robert Rick, A. T. Kearney Company; Mrs. Stoll; Seth L. Winslow, A. T. Kearney Company; Mrs. Gage, Professor Gage, University of Michigan; Lt. L. Kornfeld, U.S. Navy.

Back Row, from left to right: Clinton Brauer, Kelly Air Force Base; W. Taylor, Cincinnati MTM Chapter; Ralph Kirwin, Ernst & Ernst; E. Barnett, A. T. Kearney Company; Charles Bogenrief, Robertshaw-Fulton Controls; D. W. Karger, The Magnavox Company; Winton Etz, U.S. Air Force; R. F. Stoll, Executive Secretary, MTM Association; Serge A. Birn, Serge A. Birn Company; C. H. VanHorne, Stevenson and Kellogg, Ltd.; Robert Issacson, Argus Cameras; Ben Puddy, Stevenson & Kellogg, Ltd.; Malcolm Gotterer, Harvard University; Dudley Wells, Johnson & Johnson; Richard Keenan, International Harvester Company.

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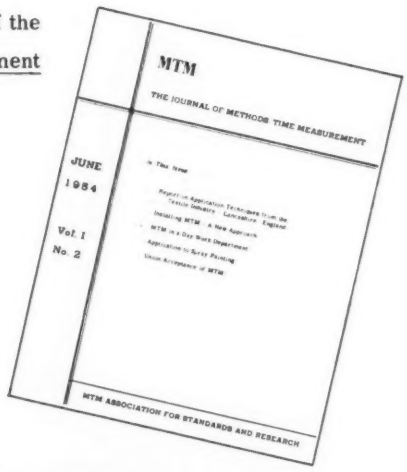

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RESEARCH REPORTS

R.R. 101 Disengage

This report contains a preliminary study of the element disengage. While it is still classified as tentative, the report contains some extremely interesting conclusions on the nature and theory of this element.

R.R. 102 Reading Operations

The first step in the use of MTM for establishing reading time standards is contained in this report. In addition, the report contains a synopsis of the work done in this field by 11 leading authorities.

R.R. 104 MTM Analysis of Performance Rating Systems

A talk presented at the SAM-ASME Time and Motion Study Conference, April 1952. It contains an analysis of performance rating systems and various performance Rating Films from an MTM standpoint.

R.R. 105 Simultaneous Motions

This report represents almost two man-years' work on a study of Simultaneous Motions. It is a final report of the Simultaneous Motions project undertaken by the MTM Association. While it does not purport to provide complete and exhaustive answers to all problems in the field of Simultaneous Motions, it presents a great deal of new and valuable information which should be of interest to every MTM practitioner.

R.R. 106 Short Reaches and Moves

This report contains an analysis of the characteristics of Reaches and Moves at very short distances. It develops important conclusions concerning the application of MTM to operations involving these short distance elements.

R.R. 107 A Research Methods Manual

The research activity of the Association has developed an effective and comprehensive set of methods for carrying on research in human motions. This report details the major techniques used. Adequate sources of motion data, film analysis, data recording, and statistical methods of analysis are among the topics discussed.

R.R. 108 A Study of Arm Movements Involving Weight

In this report, the results of a large investigation into the effect of weight on the performance times of arm movements are presented. While more effective means of determining correct time allowances for moving weights are given, the comprehensive discussion of the whole area of weight phenomena is probably of more fundamental importance. The effect of such conditions of performance as the use of one or two hands, sliding vs. spatial movements, and male and female performance are among the topics presented.


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